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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. P4620

First Inventor or Application Identifier Ankireddipally

Title TRANSACTION DATA STRUCTURE FOR PROCESS...

Express Mail Label No. EM104247435US

**APPLICATION ELEMENTS**

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages 99]  
(preferred arrangement set forth below)
  - Descriptive title of the invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 7]
4. Oath or Declaration [Total Pages ]
  - a. ☐ Newly executed (original or copy)
  - b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))  
(for continuation/divisional with Box 16 completed)
    - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

\* NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

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5. ☐ Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement verifying identity of above copies

**ACCOMPANYING APPLICATION PARTS**

7. ☐ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement of Power of Attorney  
(when there is an assignee) ☐ Attorney
9. ☐ English Translation Document (if applicable)
10. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
13. ☐ \* Small Entity Statement filed in prior application, Status still proper and desired  
(PTO/SB/09-12) ☐ Statement
14. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
15. ☐ Other: \_\_\_\_\_

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: \_\_\_\_\_ / \_\_\_\_\_  
Prior application information: Examiner \_\_\_\_\_ Group / Art Unit: \_\_\_\_\_

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

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1                   **TRANSACTION DATA STRUCTURE**  
2                   **FOR PROCESS COMMUNICATIONS AMONG**  
3                   **NETWORK-DISTRIBUTED APPLICATIONS**

4                   **CROSS-REFERENCES TO OTHER APPLICATIONS**

5           The subject matter disclosed in this application is related to subject matter  
6 disclosed in concurrently filed, commonly-assigned U.S. Patent Application No.  
7 08/XXX,XXX entitled "Interaction Protocol For Managing Cross Company Processes  
8 Among Network-Distributed Applications" (hereafter, "the Protocol patent application"),  
9 and to U.S. Patent Application No. 08/YYY,YYY entitled "Shared Transaction  
10 Processing in a Clustered Process Automation Environment". These disclosures are  
11 incorporated by reference herein for all that each teaches as if set out in full.

12                   **FIELD OF THE INVENTION**

13           The present invention relates generally to systems that manage transaction  
14 processing message flow in a distributed computer network such as the Internet. In  
15 particular, this invention provides a transaction processing system and method that make  
16 use of a novel transaction data structure for implementing transaction processing between  
17 network-distributed software applications.

18                   **BACKGROUND OF THE INVENTION**

19           Business entities have long recognized that substantial productivity and marketing  
20 benefits may potentially arise from conducting commercial business activities and

1 business processes over distributed computer networks. In order for a business to achieve  
2 the full benefits of network-based commercial activity, the firm's existing commerce-  
3 related or business process software application systems must communicate both among  
4 each other and with the application systems of other business entities. Earlier efforts at  
5 business-to-business commerce activity, such as those led by Electronic Data Interchange  
6 (EDI) applications for example, focussed on high volume transaction processing for large  
7 firms. Because of incompatible application file formats and communications protocols,  
8 and requirements for expensive application programming changes to existing systems,  
9 EDI applications were largely viewed as being commercially practical for only the largest  
10 companies and for only a select number of applications. Moreover, because of a lack of  
11 any universal data interchange formats, companies were, and still are, often prevented  
12 from exploiting their own enterprise systems integration to reach external partner  
13 applications. As a result, a business may need to spend substantial time to extract,  
14 redefine, and update data to serve specific collaborative needs with partners or customers.  
15 In addition, smaller companies with limited information technology development budgets  
16 or with old legacy systems may still be struggling with internal business systems  
17 integration issues.

18 In recent years, the Internet distributed computer network has developed the  
19 infrastructure and data communications protocols to connect all businesses to each other  
20 regardless of their size, geographic location or position in the supply chain. The Internet  
21 is a collection of interconnected individual networks operated by government, industry,  
22 academia, and private parties that use a set of standard data communications protocols to

1 form a global, distributed network. Networked distributed computer systems may be  
2 configured as intranets, extranets or publicly available systems using Internet  
3 technologies. Internet technologies provide business entities with another opportunity to  
4 achieve substantial productivity gains and marketing benefits by conducting internal,  
5 business-to-consumer and business-to-business Internet-based commercial activities  
6 among employees, and with customers, vendors, suppliers and other parties related to  
7 their business enterprises. Internet-based commercial activities, referred to generally in  
8 the current literature as "*electronic commerce*", "*e-commerce*", or "*e-business*" include,  
9 but are not limited to, all types of business processes that can take place in a secure  
10 manner online, as well as the more traditional buying and selling of goods and services.  
11 The Internet environment holds out the promise of true collaborative data exchange and  
12 software application interoperability for business firms of all sizes.

13 Several standardization efforts by industry consortia and e-commerce vendors are  
14 underway in an effort to achieve Internet application interoperability and seamless  
15 transaction processing that will appear transparent to users. One recent standard,  
16 Extensible Markup Language (XML), was adopted by the World Wide Web Consortium  
17 in February, 1998. In its broadest sense, XML is a system for defining, validating, and  
18 sharing document formats on the Web, providing a universal format for structured  
19 documents and data. XML is a markup language for presenting documents on the Web  
20 that relies on tags and is a meta-language for defining specific subject matter domains of  
21 markup tags. XML stores the definitions of tags in files called Document Type  
22 Definitions (DTDs). DTDs, also referred to as dictionaries, vocabularies, or schemas,

1 serve as a uniform source of data definitions for specific industries or fields of  
2 knowledge, making it easier to exchange data not only within an organization but also  
3 among different companies. XML is an extensible standard because users may define  
4 their own electronic document type in the form of a DTD. The simple syntax makes an  
5 XML document easy to process by machine while the tags promote human understanding  
6 of document contents. XML style sheets, called XSL, describe how the tagged data in an  
7 XML program should be displayed. Further information about XML and the World  
8 Wide Web Consortium, also known as W3C, can be found at the W3C Web site,  
9 <http://www.w3c.org>.

10 Several efforts underway to standardize transaction processing use XML. In the  
11 financial industry, for example, J.P. Morgan & Co. Inc. and Price Waterhouse Coopers  
12 recently proposed an XML dictionary called FpML (Financial products Markup  
13 Language), which would standardize XML tags in areas such as fixed income derivatives  
14 and foreign currency exchange. BizTalk is an industry initiative started by Microsoft  
15 Corporation of Redmond Washington to establish a community of standards users with  
16 the goal of driving the rapid, consistent adoption of XML to enable electronic commerce  
17 and application integration. The BizTalk design emphasis is to leverage existing  
18 applications, data models, solutions, and application infrastructure, and adapt these for  
19 electronic commerce through the use of XML. The group is defining the BizTalk  
20 Framework™, a set of guidelines for how to publish schemas in XML and how to use  
21 XML messages to easily integrate software programs together in order to build new

1 solutions. Additional information about the BizTalk Framework is available at  
2 <http://www.biztalk.org>.

3 The Internet Open Trading Protocol (IOTP) provides an interoperable framework  
4 for Internet commerce that is independent of the particular type of payment system used  
5 and is optimized for the case where the buyer and the merchant do not have a prior  
6 acquaintance. IOTP describes the content, format and sequences of messages that pass  
7 among the participants, referred to as Trading Roles, in an electronic trade. IOTP defines  
8 five different types of Trading Roles (Consumer, Merchant, Payment Handler, Delivery  
9 Handler, and Merchant Customer Care Provider) that are the ways in which organizations  
10 can participate in a trade. The IOTP framework is centered on an IOTP Transaction that  
11 involves one or more organizations playing a Trading Role, and a set of Trading  
12 Exchanges. Each Trading Exchange involves the exchange of data, between Trading  
13 Roles, in the form of a set of IOTP Messages. Each IOTP Message is the outermost  
14 wrapper for an XML document that is sent between Trading Roles that take part in a  
15 trade. An IOTP message is a well-formed XML document that contains several  
16 components including a collection of IOTP Trading Blocks (Request, Exchange,  
17 Response) that carries the data required to carry out an IOTP Transaction. An IOTP  
18 Trading Exchange consists of the exchange, between two Trading Roles, of a sequence of  
19 documents consisting of three main parts: the sending of a Request Block by one Trading  
20 Role (the initiator) to another Trading Role (the recipient), the optional exchange of one  
21 or more Exchange Blocks between the recipient and the initiator, and the sending of a  
22 Response Block to the initiator by the Trading Role that received the Request Block. For

1 more information regarding IOTP, the reader is referred to an Internet-Draft document  
2 describing Version 1.0 of the IOTP, published by the Internet Engineering Task Force  
3 (IETF) and available at the IETF web site, <http://www.ietf.org> , as of February, 2000.

4 The Open Buying on the Internet (OBI, <http://www.openbuy.org> ) standard from  
5 the OBI Consortium aims to standardize and secure the corporate purchasing model,  
6 especially the high-volume, low-dollar transactions that account for 80% of most  
7 organizations' purchasing activities. OBI's goal is to establish a common ground for  
8 what is referred to as "The Trading Web," where OBI standards adopters establish trading  
9 relationships with other OBI standards adopters through secured access to extranet  
10 facilities connected via the Internet, forming dynamic sets of interoperable systems. OBI  
11 defines an architectural approach for e-commerce systems, detailed technical  
12 specifications, guidelines for development, record layout formats, file formats,  
13 communication structures and protocols, compliance testing guidelines, and  
14 implementation assistance. The OBI standard includes precise technical specifications  
15 for the security, transport, and contents of OBI Order Requests and OBI Orders. In the  
16 currently published standard, contents of OBI Order Requests and OBI Orders are based  
17 on the ANSI ASC X.12's 850, a standard for an EDI purchase order. The OBI  
18 Consortium may provide support for XML documents in the future. For a complete  
19 discussion of the OBI technical specifications, consult version 2.0 of the Open Buying on  
20 the Internet standard available at [www.openbuy.org/obi/specs/obiv2.html](http://www.openbuy.org/obi/specs/obiv2.html) .

1 RosettaNet is an initiative by a consortium of more than thirty companies in the  
2 personal computer (PC) industry, ranging from manufacturers to resellers. Two XML  
3 data dictionaries in development will provide a common set of properties required for  
4 conducting business among Consortium members. The first is a technical properties  
5 dictionary (technical specifications for all product categories), and the second is a  
6 business properties dictionary which includes catalog properties, partner properties (i.e.,  
7 attributes used to describe supply chain partner companies) and business transaction  
8 properties. The goal is a common business language that will link the entire PC  
9 industry's supply chain. These dictionaries, coupled with the RosettaNet Implementation  
10 Framework (RNIF, an exchange protocol), form the basis for an e-commerce dialog  
11 known as the Partner Interface Process or PIP. RosettaNet's PIPs are specialized system-  
12 to-system XML-based dialogs that define how business processes are conducted between  
13 electronic component and information technology products manufacturers, software  
14 publishers, distributors, resellers and corporate end users. The purpose of each PIP is to  
15 enable the development of interoperable applications by providing common business/data  
16 models and documents that enable system developers to implement RosettaNet interfaces.  
17 Each PIP includes one or more XML documents based on Implementation Framework  
18 DTDs, specifying one or more PIP services, transactions, and messages. For further  
19 information the reader is referred to the RNIF document designated as version 1.1 and  
20 published 11/8/99, discussing the RNIF in detail, available at More information about  
21 RosettaNet is available at the Web site, <http://www.rosettanet.org>.



Private vendors, such as Ariba Technologies Inc., Commerce One Inc., and Concur Technologies Inc., are using XML to simplify the process of matching up RFPs and purchase orders over the Web. The Ariba Network platform also provides a range of Internet services for buying and selling organizations, including supplier directories, supplier catalog and content management, access to supplier content, and secure transaction routing. The Ariba Network platform is built around a multi-protocol architecture that allows buyers to send transactions from their Ariba buyer-enablement application in one standard format. The Ariba Network platform then automatically converts the order into the suppliers' preferred transaction protocol, eliminating the need for a single standard for electronic commerce and giving suppliers the freedom to transact in their preferred protocol over the Internet. Ariba Network automatically routes and translates transactions between buying organizations and suppliers using many major e-commerce standards, including Internet Electronic Data Interchange (EDI), VAN-based EDI, Open Buying on the Internet (OBI), secure HTML, e-mail, auto-FAX, Catalog Interchange Format (CIF), and a protocol known as Commerce XML (cXML). cXML defines a set of XML DTDs to describe the characteristics of non-production Maintenance, Repair, and Operations (MRO) goods and services. cXML serves as a meta-language to enable the development of "intelligent shopping agents" to assist with the corporate purchasing function. cXML's request/response messaging is used to exchange transaction data between parties. These messages provide support for purchase orders, charge orders, acknowledgements, status updating, shipment notifications, and payment transactions.

1           The public and proprietary efforts underway to standardize transaction processing  
2   in the distributed network environment are largely directed to specific industry, function  
3   or subject matter domains, such as PC supply-chain management, financial payment  
4   handling, or corporate purchasing. Thus, it appears that the standardization effort is  
5   directed to establishing predetermined descriptions of transaction message exchanges or  
6   dialogs that are specific to and optimized for a specific subject matter or industry domain.  
7   Automated commerce solutions that define interactions in terms of fixed message  
8   exchanges forgo the flexibility and adaptability required in today's dynamic  
9   marketplaces. There will be a wide range of interactions between any two parties in the  
10   marketplace that simply do not lend themselves to easy categorization or definition, and  
11   that will change over time as the business needs change and as their relationship changes.

12           XML and related data representation standardization efforts, combined with  
13   industry-based e-commerce standards efforts, clearly expand the reach of Internet-based  
14   e-business to a wider range of enterprises and are efforts in the direction of an integrated  
15   Internet e-commerce environment. But these efforts alone fall short of the complete  
16   integration needed. What is needed is a transaction processing architecture that directly  
17   supports users' needs in the marketplace and a uniform, consistent and flexible  
18   transaction definition capability that supports a full range of transaction processing in a  
19   distributed network environment.

**SUMMARY OF THE INVENTION**

The present invention is premised on the observation that a distributed network marketplace must be able to provide both services and support processes to the parties (users) who participate in the marketplace. For example, a distributor who sells items from a catalog benefits from an easy-to-use catalog update service from its suppliers, and a manufacturer benefits from the ability to request a bid with precise terms and to receive only those responses that meet the specified terms. Automated commerce solutions should allow for flexible and adaptable definition of these types of interactions to promote and facilitate dynamic marketplaces. Thus, the present invention is premised on the further observation that a comprehensive e-commerce solution must provide a framework, or architecture, that allows for the definitions of the most complex interactions between parties to be both easily configured and easily changed by the parties as their business needs change. Such a solution should also be platform independent to support a wide variety of computing environments.

The present invention provides a transaction processing architecture for a process automation application, referred to as a commerce exchange server. The transaction processing architecture is premised on a user-centric view in which a transaction is a single unit of work from the perspective of the requesting application, or client. The transaction may require several processing components to achieve its end result. However, once the user defines those components and their process flow using a unique and novel transaction definition data structure, the commerce exchange server produces

1 the messages needed to perform the transaction and manages the message flow to and  
2 from the service applications without further intervention from the user. Thus, the  
3 commerce exchange server is much more than a mere conduit for the message exchange  
4 between client and service applications.

5 In this transaction processing model, every transaction has one and only one input  
6 document sent from a requesting client application and one and only one output  
7 transaction response document sent back to the client. However, each input and output  
8 document may have multiple components, or sub-documents. This design precept  
9 provides distinct and significant advantages over other transaction processing solutions.  
10 First, it considerably simplifies the design of the commerce exchange server by limiting  
11 the message exchange between requesting and service applications. Developing client  
12 applications becomes straightforward when the client merely issues a transaction request  
13 and gets a single response back with the output it requested. In addition, the commerce  
14 exchange server takes the complexities of managing a complete transaction away from  
15 the requesting client, moving the low-level transaction processing logic common to all  
16 transactions to a single source.

17 Finally, this transaction processing model supports the three most common types  
18 of application interaction models in the e-commerce environment. These models are  
19 generally known as request/reply, publish/subscribe and broadcast. In an illustrated  
20 implementation of the commerce exchange server, the request/reply interaction model  
21 allows two parties to exchange information in an asynchronous, or non-blocking, fashion.

1 In asynchronous messaging, the requesting application sends a transaction request to the  
2 commerce exchange server and may continue its own processing, without waiting for the  
3 transaction to be processed. An acknowledgement response is sent that contains tracking  
4 information that allows the requesting party to query the status of the transaction request.

5 In a publish/subscribe interaction model, two applications interact via an intermediary  
6 party. The applications that are interested in specific information register with the  
7 intermediary party. The information generating application posts, or publishes, the  
8 information to the intermediary, which in turn passes this to the registered parties. In this  
9 model, the information requestor and the information supplier never interact directly.

10 The broadcast model is a special case of a model known as the multicast model, both of  
11 which send a message to the members of a group of parties who support the requested  
12 operation. When the group size is less than the entire membership of a domain, a  
13 message is broadcast to the group; when the group size equals the entire membership,  
14 sending the message to the entire group is referred to as multicasting. The message sent  
15 in this type of interaction model is typically one of two types: a request message,  
16 resulting in a reply message returned, or a notify message that simply reports information  
17 or events. Note also that in the multicast interaction model, the recipient group may or  
18 may not be subscription based. The information receiver application determines this  
19 from the content of the broadcast message. The transaction model of the present  
20 invention provides support for all three interaction models.

21 The transaction processing architecture is further premised on the discovery of a  
22 novel transaction definition data structure. This data structure allows the user to define a

1 transaction composed of component operations and to define the order of those  
2 operations, including determining whether an operation is a broadcast operation or  
3 whether more than one operation should be performed concurrently before proceeding to  
4 a next operation. The data structure also allows the user to specify the source of input  
5 data needed to perform each operation and to place conditional logic on the execution of  
6 an operation, based on results of one or more previously executed operations. The  
7 transaction definition data structure allows a transaction to be specifically customized to  
8 the business needs of the user who defines the transaction.

9 In an illustrated embodiment of the present invention, the transaction definition  
10 data structure is an XML document that includes multiple OPERATION sections for  
11 specifying the component operations that make up the transaction. An input section,  
12 referred to as a JOIN section, within an OPERATION section of the XML document  
13 includes markup tags for specifying the source of input data needed. A conditional logic  
14 section, referred to as a SPLIT section, within an OPERATION section of the XML  
15 document includes markup tags for specifying whether a subsequent operation in the  
16 operation flow should be conditioned on the output of a previous operation.

17 The transaction processing architecture supports this flexible and adaptable  
18 transaction definition model. The user provides a unique transaction identifier for each  
19 transaction definition, stores them in a database of definitions, and then simply requests  
20 that a transaction be performed by its transaction identifier. The transaction processing  
21 architecture of the present invention defines a transaction service that performs several

1 essential functions. The transaction service obtains the appropriate definition, builds an  
2 internal transaction processing data structure and performs the transaction. In an  
3 illustrated implementation of the transaction service, all transaction definitions stored in  
4 the database are loaded at start-up of the commerce exchange server, and the transaction  
5 service obtains the appropriate definition from memory. In an alternate implementation  
6 the transaction service may retrieve the appropriate definition directly from the database.  
7 In the illustrated embodiment described herein, the internal transaction processing data  
8 structure, referred to as a transaction instance, is a directed acyclic graph (DAG) with the  
9 conditionals and mapping functions and logic to represent the definition of the  
10 transaction. The transaction service then creates and maps the XML documents with  
11 input and output variables in order to create and send the various messages needed for  
12 transaction execution. The transactions service evaluates the conditional logic and  
13 traverses through the DAG in order to execute the transaction, and produces and sends an  
14 output response to the requesting application.

15 The commerce exchange server, including the transaction processing architecture  
16 that makes use of the novel transaction definition data structure, may be implemented in  
17 any type of distributed network of processor-controlled machines such as, for example, in  
18 the Internet environment. Protocols for implementing message exchanges in the Internet  
19 environment are disclosed in the Protocol patent application referenced above.

20 Therefore, in accordance with one aspect of the present invention, there is  
21 provided an XML (extensible markup language) transaction definition document stored

1 on a computer-readable medium comprising a plurality of operation data portions each  
2 defining an operation. The plurality of operations collectively define a transaction. Each  
3 operation data portion, when parsed by a process automation application, causes the  
4 process automation application to communicate with a service application program to  
5 perform the operation. At least one operation data portion comprises a conditional logic  
6 data portion that, when parsed by the process automation application, causes the process  
7 automation application to condition performance of a next operation on evaluation of  
8 operation response data from performing the operation.

9 In another aspect of the invention, at least one operation data portion included in  
10 the XML transaction definition document indicates a broadcast operation and includes a  
11 broadcast data portion. When parsed by the process automation application, the  
12 broadcast data portion causes the process automation application to communicate with a  
13 plurality of service applications to cause each service application to perform the  
14 operation. In a further aspect of the invention, the broadcast data portion further includes  
15 an expression data portion indicating at least one of a mathematical expression, a  
16 function, and a variable data item. When parsed by the process automation application,  
17 the expression data portion causes the process automation application to evaluate the at  
18 least one of the mathematical expression, the function, and the variable data item using  
19 the operation response data to determine the success or failure outcome of the broadcast  
20 operation.



1 In another aspect of the present invention, there is provided a transaction  
2 definition data structure stored on a computer-readable medium comprising a plurality of  
3 operation data portions indicating a plurality of operations collectively defining a  
4 transaction. Each operation data portion defines an operation. Each operation data  
5 portion comprises an operation identifier uniquely identifying the operation among the  
6 plurality of operations, a service application name indicating a service application for  
7 performing the operation, an input data portion indicating input data used by the service  
8 operation for performing the operation, and a conditional logic data portion indicating  
9 evaluation data conditioning performance of the next operation on evaluation of operation  
10 response data received from the service application performing the operation.

11 In another aspect of the present invention, there is provided a computer-  
12 implemented method for performing a transaction comprising the steps of producing a  
13 transaction instance data structure indicating a plurality of operations constituting a  
14 transaction. The transaction instance data structure indicates a linking of the plurality of  
15 operations to indicate an operation performance order. The transaction instance data  
16 structure further indicates conditioning logic data for changing the operation performance  
17 order such that the plurality of operations is capable of being performed in more than one  
18 possible order. The computer-implemented method for performing a transaction further  
19 includes, for each of the plurality of operations, producing an operation request message  
20 indicating input data for performing an operation, sending the operation request message  
21 to a service application to perform the operation using the input data, receiving an  
22 operation response message from the service application indicating output data from the

1 operation, and determining a next operation to perform using the conditioning logic data  
2 and the output data of the operation response message.

3 In yet another aspect of the present invention, there is provided a distributed  
4 transaction processing system comprising a plurality of service application programs each  
5 capable of performing an operation, and a data store including a plurality of transaction  
6 definitions. Each transaction definition indicates a transaction definition name uniquely  
7 identifying the transaction definition and a plurality of operation definitions indicating a  
8 plurality of operations constituting a transaction. The distributed transaction processing  
9 system further comprises a requesting application program that produces a transaction  
10 request message indicating a transaction definition name identifying one of the plurality  
11 of transaction definitions included in the data store, and a computer having a memory  
12 device for storing a process automation application. The process automation application  
13 receives the transaction request message indicating the transaction definition name from  
14 the receiving application program and uses the transaction definition name to obtain the  
15 transaction definition from the data store. The process automation application produces  
16 an operation request message for each operation definition included in the plurality of  
17 operation definitions and sends the operation request messages to at least one service  
18 application program. The at least one service application program sends an operation  
19 response message to the process automation application in response to receiving an  
20 operation request message. The process automation application produces a transaction  
21 response message using the operation response messages, and sends the transaction  
22 response message to the requesting application.

1       The novel features that are considered characteristic of the present invention are  
2 particularly and specifically set forth in the appended claims. The invention itself,  
3 however, both as to its organization and method of operation, together with its  
4 advantages, will best be understood from the following description of an illustrated  
5 embodiment when read in connection with the accompanying drawings. In the Figures,  
6 the same numbers have been used to denote the same component parts or steps.

### 7                   **BRIEF DESCRIPTION OF THE DRAWINGS**

8       FIG. 1 is a block diagram schematically illustrating a systems architecture for  
9 managing transaction message flow in a distributed computer network according to the  
10 present invention;

11       FIG. 2 is a block diagram showing the types of messages and the general  
12 message flow of a transaction between the transaction service component and the service  
13 and requesting applications of FIG. 1;

14       FIG. 3 schematically illustrates the inputs to the transaction service function of  
15 producing an operation request document according to an illustrated embodiment of the  
16 invention;

17       FIG. 4 schematically illustrates the inputs to the transaction service function of  
18 producing an operation response document according to an illustrated embodiment of the  
19 invention;

1           FIG. 5 is a block diagram schematically illustrating the major entities of the  
2 transaction data structure and their organization;

3           FIG. 6 schematically illustrates a first portion of the DTD of the XML  
4 document that functions as the transaction data structure according to an illustrated  
5 implementation of the present invention;

6           FIG. 7 schematically illustrates a second portion of the DTD of the XML  
7 document that functions as the transaction data structure according to an illustrated  
8 implementation of the present invention;

9           FIG. 8 is a flowchart illustrating transaction processing as performed by the  
10 transaction service of FIG. 2 and using the transaction definition data structure of FIG. 5,  
11 according to an illustrated implementation of the present invention; and

12           FIG. 9 is a simplified block diagram illustrating a distributed computer network  
13 including several processor-controlled machines, showing the components of one suitably  
14 configured processor-controlled machine in which the present invention may be used, and  
15 further illustrating the software product of the present invention and its use in conjunction  
16 with a machine in the network.

**DETAILED DESCRIPTION OF THE INVENTION**

**1. A commerce server architecture utilizing the transaction data structure.**

**a. Process components.**

FIG. 1 illustrates a system architecture for enabling application-to-application interaction in a distributed computer network. Specifically, the system architecture of FIG. 1 illustrates an inter- or intra-enterprise Internet-based electronic commerce architecture including process automation application 10, referred to as a commerce exchange (CX) server. CX server 10 operates as a type of clearinghouse, receiving operation requests posted by client components 34 and 38 and directing them to appropriate service components 26, 28 and 30 identified ("signed up") to CX server 10 as being available to perform those services. In this capacity, much of the processing performed by CX server 10 involves searching for service component by service operation and searching for client components by their identification numbers. CX server 10 also performs a variety of administrative functions including transaction tracking and audit functions and disaster recovery functions.

Each application component is referred to as a commerce exchange component, or CXC. As shown in FIG. 1, there may be any number of CXCs identified to CX server 10. A CXC application either provides one or more services or originates a transaction request, or both. A CXC application may be integrated with CX server 10 as a built-in component residing on the same machine or it may be a third party application resident on a different machine. For example, service application 30 is resident on machine 24

1 and accessible to CX server 10 via communications connection 29, and requesting  
2 application 38 is resident on machine 36 and accessible to CX server 10 via  
3 communications connection 35. The type of architecture model illustrated in FIG. 1 may  
4 be variously described in the literature as an information bus model, a client-server model  
5 or a cooperative agent model.

6 i. Communication Service.

7 CX server 10 includes several processing services: Communication service 12;  
8 XML/DOM service 14; Transaction service 200; and Persistence service 19.  
9 Communication service 12 provides interfaces for accepting and establishing  
10 connections, and sending and receiving messages through various network transport  
11 protocols. In an illustrated implementation of CX server 10, the network transport  
12 protocol supported is TCP/IP, but other transport protocols may be supported as well.  
13 Communication service 12 also provides a variety of other communications-related  
14 services including notification of broken connections, fragmentation and assembly of  
15 messages, and connection-level session management and handshaking functions.

16 ii. Application Interaction Protocol Processing.

17 CX server 10 also includes an application interaction protocol processing function  
18 400. CX server 10 is a document-centric process automation application, exchanging  
19 messages in the form of XML documents 40 between CXCs. These XML documents  
20 form the underlying message exchange protocol, referred to as the Commerce Exchange  
21 Interaction Protocol, hereafter CXIP. Standardizing the messaging format in this manner

allows for the straightforward integration of third party applications as CXC's, without the absolute requirement for application-specific libraries. Each CXC includes two software interface components (not shown) for extracting transaction data from XML-based message 40. A transportation/communication module handles the syntax and semantics of the Application interaction message received from CX server 10 over the particular communications transport mechanism (e.g., TCP/IP), receiving a message and returning an XML document. Then, an XML/DOM (Document Object Model) module receives the XML document output produced from the transportation/communication module, parses the document and returns one or more DOM objects that are passed to the application logic for handling as standard program objects. The use of DOM objects is discussed in more detail below. A CXIP message is in the data representation format specified by XML, which is presumed to be an 8-bit character format in the present implementation. Sending and receiving applications have the responsibility of encoding and decoding data embedded inside a CXIP message.

The present implementation of CXIP supports eight (8) message types that implement the three most common application interaction models (Request/Reply, Publish/Subscribe and Broadcast) in the Internet environment. These eight message types are Request, Reply, Cancel, Publish, Notify, Subscribe, Unsubscribe, and Acknowledge. An Acknowledge message is a special type of message used to acknowledge receipt of all of the other message types. An Acknowledge message may contain any information needed for tracking purposes, such as for querying the status of a prior request, or purposes of establishing an audit trail or transaction log. An application

1 should follow the application interaction protocol by sending an Acknowledge message  
2 for each received message, except for the Acknowledge message itself. Application  
3 interaction models may be implemented in either synchronous or asynchronous mode.  
4 An illustrated implementation of CX server 10 operates in asynchronous mode, also  
5 referred to as the offline, or non-blocking, model. The Protocol patent application  
6 provides additional details about an illustrated implementation of the application  
7 interaction protocol.

8 The basic transport assumption in the application interaction protocol, CXIP, used  
9 by CX server 10 is the guaranteed delivery of messages. As long as this requirement is  
10 satisfied, the underlying transport protocol may be any standard communications  
11 protocol. As noted above, the present implementation of CXIP is based on TCP/IP. In  
12 this implementation, CXIP messages are transmitted as TCP data between applications.  
13 A field size data item in the fixed-length message header of a CXIP message indicates the  
14 length of the associated message content in byte counts so that the receiver may easily  
15 determine the end of a message without having to test for a special message-termination  
16 character. CXIP may also be implemented on top of other transport mechanisms such as  
17 SMTP and FTP. Cooperating applications (CXCs) based on different transportation  
18 mechanisms (e.g., SMTP or FTP ) are implemented by including a bridging mechanism  
19 in Communication service 12 (not shown) for translating messages between TCP/IP and  
20 SMTP and FTP message formats. To enable HTTP-based interactions a MIME type may  
21 be defined, such as "*application/x-cxip-v10*", and it is straightforward to develop a  
22 browser plug-in to handle CXIP messages.



1           iii.     Transaction Service.

2           Transaction service 200 provides interfaces for working with transaction logic,  
3 tracking a transaction thread, traversing transaction logic and performing transaction  
4 execution. CX server 10 provides a virtual workspace, or transaction execution space, to  
5 participating (registered) CXC applications. A CXC submits a transaction request based  
6 on a published CX transaction document type declaration (DTD). Upon receipt of a  
7 transaction, CX server 10 identifies the set of operations that comprise the transaction  
8 based on a transaction definition in data store 18, and then executes the transaction by  
9 providing operation requests to CXCs identified as registered to perform the respective  
10 operations. Each invoked CXC performs the specified operation request(s) and sends  
11 back results to CX server 10, which, after completion of all operation requests, returns the  
12 transaction response back to the originating CXC. A transaction definition takes the form  
13 of a directed acyclic graph. CX server 10, with knowledge of the transaction logic from  
14 the transaction definition, controls all processing decisions including which operations to  
15 perform, to which CXC to forward an operation request, how to process the conditions on  
16 the services, which information to pass and receive, and when to terminate processing.

17           iv.     XML/DOM Service.

18           XML/DOM service 14 provides interfaces and services for handling the XML  
19 documents 40 that form the basis of the message exchange protocol. Services include  
20 parsing and constructing XML documents, and building and accessing DOM (Document  
21 Object Module) object trees. The Document Object Model (DOM) is a platform- and  
22 language-neutral application programming interface (API) for HTML and XML

1 documents that models these documents using objects. The DOM provides a standard set  
2 of objects for representing HTML and XML documents, a standard model of how these  
3 objects can be combined, and a standard interface for accessing and manipulating them.  
4 As an object model, the DOM identifies the semantics of these interfaces and objects,  
5 including both behavior and attributes, and the relationships and collaborations among  
6 these interfaces and objects. Because of its platform- and language-independent format,  
7 the DOM is used as an interface to proprietary data structures and APIs, instead of  
8 product-specific APIs, in order to achieve application interoperability with less effort.  
9 Additional information regarding the DOM may be found at <http://www.w3.org/DOM/>.

10 XML/DOM service 14 may make use of any public domain XML parser.  
11 Although the XML-based document messaging format is primarily used for exchanging  
12 active messages, some internal data used by CX server 10 are also represented and stored  
13 as XML documents. For example, the transaction directed acyclic graph that defines the  
14 component services of a transaction is an XML document. Therefore, other service  
15 components, such as transaction service 200, may use XML/DOM service 14 for  
16 translation between XML syntax and an internal data format requirement.

17 v. Persistence Service.

18 Persistence service 19 provides interfaces for storing information into and  
19 retrieving information from external data stores 18. From the perspective of CX server  
20 10 or a CXC, data entering into or coming from data stores 18 are in XML document  
21 format. Persistence service 19 has the responsibility of mapping between an XML

1 document and the respective data store schema. In an illustrated implementation of CX  
2 server 10, data stores 18 include a Netscape™ message server, a Netscape™ LDAP  
3 server, and an Oracle™ database server. Support for flat files is also possible. Examples  
4 of information that are included in data stores 18 are system parameters, events and alerts,  
5 and transaction definitions.

6 **b. Process and Threading models.**

7 CX server 10 executes as a single process that listens to one listener port and one  
8 administrative port for application protocol (CXIP) messages. The single process model  
9 distinguishes CX server 10 from conventional application servers that follow the  
10 traditional multi-process model. The single process model is critical to the  
11 implementation of conditional-logic transaction processing and the complexities of event  
12 notification and process control over the CXCs. Moreover, the single process model  
13 simplifies administration of the CX server 10 by the system administrator, and is more  
14 efficient in database access than a multi-process model. In addition, a single multi-  
15 threaded process is typically more efficient than multiple single or multi-threaded  
16 processes because it uses fewer system resources such as memory and disk space,  
17 assuming that each thread is scheduled as having the same priority as the kernel thread.  
18 The capability of deploying a backup CX server addresses the problem of a single point  
19 of failure caused by using a single process model.

20 CX server 10 supports both a single-thread and multi-thread model. A single-  
21 threaded CX server listens to both the administrative and listener ports at the same time

1 and processes incoming request one after another, in serial fashion. Priority processing is  
2 not supported and event processing support is restricted. The single-thread model does  
3 not allow for the CX server to load CXC libraries. The multi-threaded CX server uses  
4 multiple threads for listening and accepting connections from the administrative port,  
5 listening and accepting connections from the listener port, listening and receiving  
6 messages from established connections, priority processing of transactions (messages),  
7 and executing CXC libraries loaded as part of the process. The multi-threaded model  
8 supports both serial and non-serial processing of requests. Serial and non-serial  
9 processing are distinguished by whether the message listening thread waits for  
10 termination of the thread that is created to process the message. Threading and  
11 serialization are determined by configuration parameters provided at startup.

12 In one embodiment of CX server 10, a commerce exchange component (CXC) is  
13 expected to establish a persistent connection, throughout the lifetime of the CXC, to the  
14 CX server and to use the connection for all message exchanges. The CX server uses the  
15 connection to determine the existence of the CXC in the network. Each message received  
16 through a persistent connection is processed concurrently using an independent thread.  
17 This implementation improves message-processing performance, minimizes the usage of  
18 system resources, and eliminates the overhead of establishing and terminating a  
19 connection for each new request.

20 In the illustrated implementation of CX server 10 herein, CX server 10 supports  
21 asynchronous transaction processing. That is, when an operation request is sent from CX

1 server 10 to a CXC, the processing thread does not block for a response from the CXC  
2 and instead sets the state of the transaction and exits from the thread. When a response  
3 message is received, the transaction is executed based on the state and the type of  
4 response. Support for asynchronous transaction processing achieves efficiency from the  
5 single shared connection between CX server 10 and a CXC. Requests may be sent from  
6 the CX server simultaneously in multiple threads and the responses may be returned in  
7 any order according to how the CXC process them, without waiting for the requests to be  
8 performed serially. In addition, timer events may be introduced more easily, thus  
9 creating an event-driven processing model.

10 **c. Distributed transaction processing support.**

11 FIG. 1 also illustrates a representative configuration of the application architecture  
12 required to implement transaction processing in a distributed computer network such as  
13 the Internet. This application architecture makes use of the Document Object Model  
14 (DOM) described above. Service application 30 and requesting (client) application 38  
15 each includes transportation/communication module 44 for handling the syntax and  
16 semantics of application interaction message 40 received from CX server 10 over a  
17 TCP/IP transport mechanism. Transportation/communication module 44 receives  
18 message 40 as TCP/IP data and returns an XML document. In service application 30,  
19 XML/DOM module 42 receives the XML document output produced from  
20 transportation/communication module 44, parses the document and returns one or more  
21 DOM objects that are passed to service application logic 21 for handling as standard  
22 program objects. Similarly, in requesting application 38, transportation/communication

1 module 44 receives message 40 as TCP/IP data via communications path 35 and returns  
2 an XML document. XML/DOM module 46 then receives the XML document output  
3 produced from transportation/communication module 44, parses the document and  
4 returns one or more DOM objects that are passed to application logic 37 for handling as  
5 standard program objects. This component module application architecture enables any  
6 third party application to be straightforwardly integrated as a commerce exchange  
7 component (CXC) in the domain of a commerce exchange server. Development of these  
8 component modules is technically straightforward in either Java or C++ implementations.

9 CX server 10 also supports distributed transaction processing. A CX server in  
10 one enterprise or network may communicate with a CX server in another enterprise or  
11 network to cooperatively fulfil transaction requests. Thus, one CX server 10 that cannot  
12 fulfil a service component of a transaction request using a participating CXC in its own  
13 domain may send the operation request to another CX server (not shown in FIG. 1) that  
14 includes a participating CXC that has the capability to perform the service. This feature  
15 enables an enterprise or group of enterprises to deploy cooperating commerce exchange  
16 applications. Note also that, while FIG. 1 shows TCP/IP as the message transport  
17 protocol, transportation module 44 may be implemented on top of SMTP or FTP as well.  
18 Cooperating applications (CXCs) based on different transportation mechanisms may also  
19 be implemented by developing a bridge that translates messages from one protocol to  
20 another.

1    **2.     Transaction message types and message flow.**

2           Preliminary to describing transaction processing and its associated data structures,  
3   definitions are provided for some terminology that has specific meanings in the context of  
4   the present invention. These terms have the meanings given here throughout this  
5   disclosure, rather than any meanings that may occur in other sources, such as, for  
6   example, in documents, if any, that are incorporated by reference herein elsewhere in this  
7   description.

8           The term *data* or *data item* refers herein to physical signals that indicate or  
9   include information. Data includes data existing in any physical form, and includes data  
10   that is transitory or is being stored or transmitted. For example, data could exist as an  
11   electromagnetic or other transmitted signal or as a signal stored in electronic, magnetic or  
12   other form. A *data structure* as used herein is any combination of interrelated data items.  
13   For example, an XML document is a data structure. A data item *indicates* a thing, an  
14   event or a characteristic when the item has a value that depends on the existence or  
15   occurrence or the measure of the thing, event or characteristic. A first item of data  
16   indicates a second item of data when the second item of data can be obtained from the  
17   first item of data, when the second item of data can be accessible using the first item of  
18   data, when the second item of data can be obtained by decoding the first item of data, or  
19   when the first item of data can be an identifier of the second item of data.

20           An *operation* is a single, atomic process that acts upon input data to achieve a unit  
21   level function. An operation may sometimes be referred to as a *service*. The CX server

1 handles an operation as a single unitary process, while the scope and nature of the  
2 processing involved in an operation is defined by the service application that performs the  
3 operation. A *transaction* is a set of one or more operations that are to be performed in a  
4 defined order under given conditions by one or more participating service applications.

5 A *transaction definition* is a data structure that defines a type or category of valid  
6 transaction to CX server 10. A transaction definition includes the component operations  
7 that constitute the transaction, the identity of the input data items required to perform  
8 each operation and the source of values for that data. A transaction definition also  
9 includes process flow information that indicates conditional logic, if any, to be applied to  
10 a component operation, and the data items and format of the output results of the  
11 transaction. Note that a transaction definition may include only one transaction. A  
12 *transaction database* is a collection of one or more transaction definitions. Each  
13 transaction definition includes a unique identifier within a given domain referred to  
14 herein as a *transaction definition name*.

15 Every transaction definition conforms to a *transaction directed acyclic graph* data  
16 structure, or *transaction DAG*. That is, the transaction DAG specifies the ordered set of  
17 data items that are both required and optional for a transaction definition. A directed  
18 acyclic graph is known in the art as a set of nodes and a set of ordered pointers between  
19 the nodes that define at least one path through the graph, subject to the constraint that no  
20 path starts and ends with the same node.



1       A *transaction instance data structure*, or *transaction instance*, is a specific  
2 implementation of a transaction definition that indicates the specific data to be used to  
3 perform the transaction defined by the transaction definition. Thus, a transaction  
4 definition may be viewed as providing a template for producing a transaction instance  
5 when provided with specific input data on which to operate. A transaction instance has a  
6 unique identifier within a given domain, referred to as a *transaction ID*, associated with  
7 it.

8       In the illustrated implementation of the transaction service described below, a  
9 transaction definition is specified using *Extensible Markup Language*, or *XML*, and so is  
10 a data object called an *XML document*. *XML* describes a class of data objects called XML  
11 documents and partially describes the behavior of computer programs that process them.  
12 XML is an application profile or restricted form of SGML, the Standard Generalized  
13 Markup Language [ISO 8879]. By construction, XML documents are conforming SGML  
14 documents. Each XML document has both a logical and a physical structure. Physically,  
15 the document is composed of units called entities. An entity may refer to other entities to  
16 cause their inclusion in the document. A document begins in a "root" or document entity.  
17 Logically, the document is composed of declarations, elements, comments, character  
18 references, and processing instructions, all of which are indicated in the document by  
19 explicit markup declarations. The logical and physical structures must nest properly, as  
20 described in "4.3.2 Well-Formed Parsed Entities" in the World Wide Web Consortium  
21 XML specification. A software module called an XML processor is used to read XML

1 documents and provide access to their content and structure. It is assumed that an XML  
2 processor is doing its work on behalf of another processing entity or module.

3 An XML *document type declaration* contains or points to markup declarations  
4 that provide a grammar for a class of documents. This grammar is known as a *document*  
5 *type definition*, or *DTD*. The document type declaration can point to an external subset  
6 containing markup declarations, or can contain the markup declarations directly in an  
7 internal subset, or can do both. The DTD for a document consists of both subsets taken  
8 together. An XML document is *valid* if it has an associated DTD and if the document  
9 complies with the constraints expressed in its associated DTD. An XML document is a  
10 *well-formed XML document* if the document, taken as a whole, matches the XML  
11 production labeled “document,” meets all the constraints with respect to being well-  
12 formed given in the XML specification, and each of the parsed entities referenced directly  
13 or indirectly within the document is well-formed. A well-formed XML document may  
14 also be valid if it meets additional criteria, as specified in World Wide Web Consortium,  
15 *Extensible Markup Language (XML) 1.0: W3C Recommendation* 10-February-1998.)  
16 Additional information about XML is available at <http://www.w3.org/XML> and  
17 [www.w3.org/TR/PR-xml-971208](http://www.w3.org/TR/PR-xml-971208).

18 FIG. 2 illustrates the components of an illustrated embodiment of the transaction  
19 service architecture and the message types associated with a transaction instance.  
20 Transaction service 200 is responsible for producing some of the messages involved in  
21 performing a transaction, and for managing the message flow necessary to perform a

1 transaction. FIG. 2 shows the transaction message flow and assumes that messages are  
2 received by CX server 10 and, after processing by other components (e.g.,  
3 communications service 12 and application interaction protocol processing service 400),  
4 are passed to transaction service 200. There are four types of messages managed by  
5 transaction service 200. These are a transaction request message, an operation request  
6 message, an operation response message, and a transaction response message. Note that  
7 in the illustrated embodiment of CX server 10 described herein, each of the four types of  
8 messages is an XML document that conforms to the application interaction protocol  
9 handled by application interaction protocol processing service 400 (FIG. 1) and described  
10 in the Protocol patent application.

11 A requesting (or originating) application 34 submits a *transaction request* 284 to  
12 transaction service 200. Transaction request 284 is a data structure that indicates a  
13 request to process a transaction according to the transaction definition identified by a  
14 transaction definition name included in transaction request 284. A transaction is single  
15 unit of work from the perspective of the requesting application, or client. In the  
16 transaction processing model of CX server 10, every transaction has one and only one  
17 input document and one and only one output document, although each input and output  
18 document may have multiple sub-document components. Transaction service 200  
19 receives request 284 and uses the transaction definition name to obtain the appropriate  
20 transaction definition 282. In the illustrated implementation of transaction service 200,  
21 all transaction definitions 280 included in transaction database 296 are loaded into  
22 memory at the start-up of CX server 10. However, transaction service 200 could also

1 retrieve the appropriate transaction definition 282 from among all transaction definitions  
2 280 included in transaction database 296.

3 Transaction service 200 uses transaction DTD 50, transaction definition 282 and  
4 transaction request 284 to produce a transaction instance data structure 270 (FIG. 3). The  
5 transaction instance is an internal data structure that transaction service 200 uses to  
6 perform the requested transaction. In an illustrated embodiment of transaction service  
7 200, the transaction instance data structure is a directed acyclic graph. For every  
8 operation included in the transaction instance, transaction service 200 produces an  
9 *operation request document* 286. Operation request document 286 is sent to a service  
10 application 26 (a CXC) to perform the operation. FIG. 3 schematically shows the  
11 production of operation request document 286 using transaction definition 282,  
12 transaction request 284, transaction instance 270 and transaction DTD 50. Transaction  
13 service 200 uses transaction definition 282 and transaction request 284 to produce  
14 transaction instance 270, which includes information about each operation in the  
15 transaction. Each operation is uniquely identified within transaction instance 270 and  
16 includes the name of the service application that is to perform that operation. Transaction  
17 service 200 obtains the input data needed for execution of the named operation from  
18 transaction request 284 and provides it in operation request document 286 according to  
19 specifications provided in transaction instance 270. Additional information about the  
20 content of the operation request document and how it is produced is discussed below.

Returning again to FIG. 2, transaction service 200 may send several operation request documents 286 to a single service application 26, and may send operation request documents 286 from a single executable transaction to several service applications 26 and 30. When a service application 26 completes an operation, it produces an *operation response document* 290 indicating the results of the operation and sends operation response document 290 to transaction service 200. Operations within a transaction instance are performed according to an order specified in transaction definition 282. Thus, transaction service 200 tracks the receipt of operation response documents both to determine what operation(s) to perform next and to determine when a transaction instance is complete. Transaction service 200 may use operation results included in an operation response document 290 to produce a subsequent operation request document 286 for a subsequent operation to be executed.

When all operations of a transaction instance have been completed, transaction service 200 produces a transaction response document 294, as shown schematically in FIG. 4, using operation response documents 290, and transaction instance 270. Transaction service 200 obtains from transaction instance 270 the format in which the originating requesting application expects to receive the output results of a completed transaction, and prepares transaction response document 294 using the results provided in operation response documents 290. Then, as shown in FIG. 2, transaction service 200 returns transaction response document 294 to requesting (originating) application 34.

**3. Description of the Transaction DAG Data Structure.**

**a. Functional components of a transaction.**

Transaction definition 282 of FIG. 2 serves as a template for a specific transaction instance and is an XML document having the logical and physical structure specified by its associated transaction DTD 50. The general organization and major functional entities of the transaction directed acyclic graph data structure 50 are schematically illustrated in FIG. 5, with each functional entity shown as a named rectangular box. The identifying data entity names used in FIG. 5 are not intended to limit the data structure in any way. The data entities are illustrated in a hierarchy to show each entity's constituent parts. An entity that may have more than one occurrence is illustrated by multiple offset boxes. Each occurrence includes all of the entities at lower levels in the hierarchy. Entities that are composed of the same data items are labeled with the same reference numbers. An entity that is required is shown with its box in solid outline while the box of an optional entity is shown with a dark dashed outline. A required entity indicates that either the data is explicitly included in the data structure or the necessary data is obtained from some other source by default. The entities that exist below an optional entity in the hierarchy are shown as being either required or optional for the case when the optional higher level entity is present in the transaction. Because an XML DTD expresses both a logical and a physical structure, some of the data entities have logical processing associated with them. The entities and their processing behaviors are defined as follows. Note that the interpretation of DTD 50 described below are defined by a specific implementation of transaction service 200, and are not associated with the DAG data structure. For

1 example, the default behaviors that are described below when no value is provided for a  
2 tag or when an optional section is missing indicate the specific interpretation of the  
3 illustrated embodiment described herein. The interpretation of DTD 50 described below  
4 thus reflect an illustrated embodiment of transaction service 200, and other interpretations  
5 are also possible.

6 A transaction instance is composed of a set of ordered operations 54. In the  
7 directed acyclic graph, an operation is represented by a node in the graph. Every  
8 transaction has two specific nodes, or operations, called the head operation and the tail  
9 operation. Operations 61 and 63 are shown as the head and tail operations respectively.  
10 Operation flow within a transaction always proceeds from the head operation to the tail  
11 operation. There may be one or more operations between the head and tail operations but  
12 each operation is performed only once. Note that if the operation is a broadcast  
13 operation, it is still considered to be performed only once, even though the operation may  
14 be sent to many service applications to be performed. There may be more than one  
15 possible path through the graph from the head operation to the tail operation, and one of  
16 those possible paths is executed at runtime. Thus, the path through the graph for a given  
17 transaction definition will not necessarily be the same for each transaction instance of that  
18 transaction definition because of differing run time conditions.

19 Each operation is defined to include five functional entities: name 55, Service  
20 application name 57, INPUT 60, CONDITIONAL LOGIC 58 and OPERATION  
21 LINK(S) 56. These entities provide the information used to produce the operation

1 request document 286 used by a service application to perform this operation and to  
2 provide conditional logic to determine which operation(s) is to be performed after the  
3 completion of this operation. A unique operation name 55 represents the operation  
4 within the context of its transaction. A service application, or CXC, name 57 specifies  
5 the service application that can perform this operation. Note that the name of the  
6 operation can be determined at run-time by looking up a CXC which has signed up to  
7 perform that operation.

8 The INPUT entity, which is the only required entity, provides information  
9 sufficient to prepare the operation's operation request document 286 (FIG. 2 and FIG. 3).

10 A list of expressions 60, referred to as INPUT entity logic, is used to build the input  
11 arguments for the operation request message 286 for the operation to which this INPUT  
12 entity belongs. If the processing for the INPUT entity fails, the operation will not be  
13 executed. If no INPUT entity is provided, a default INPUT consolidates all of the  
14 preceding operations' operation response documents 290 into the operation request  
15 document 284 for this operation. The ARGUMENT component 66 provides an argument  
16 to add to the operation request document 286 for this operation. It specifies the name and  
17 type of the argument along with a tag indicating if it is required or optional. The  
18 associated EXPRESSION component 70 defines how to derive the value for this  
19 argument. An argument may derive its input data from another document, or generate a  
20 value based on some EXPRESSION. DOCUMENT component 72 identifies an XML  
21 document and defines how that document should be mapped to the indicated argument  
22 (ARG). It defines the operation that contains the document and the relevant section(s) of



1 the document to extract. Transaction DAG structure 50 also includes runtime data in the  
2 form of OUTPUT entity 59 which includes DOCUMENT entity 73, for use in assembling  
3 the output response document.

4 An important feature of DAG structure 50, and the reason that there may be more  
5 than one possible path through a transaction instance graph, is that the execution of one or  
6 more of OPERATIONS 54 (except for operations 61 and 63) may be conditioned on the  
7 output of previous operations. The OPERATION LINK((S) component 56 refers to  
8 explicit links between the present (source) operation and a destination (next) operation.  
9 Whenever the operation identified as the source operation completes, the operation  
10 identified as the destination operation is considered for possible execution. Evaluation  
11 for execution is accomplished using the CONDITIONAL LOGIC (CL) entity 58. CL  
12 entity 58 is used to decide which operations to consider for execution whenever the  
13 operation to which the CL entity belongs completes execution. It is comprised of a series  
14 of statements (STMT) 64 that include an EXPRESSION entity 70 which is evaluated,  
15 typically using the output results of the completed operation. For each statement that  
16 evaluates to a true condition, the list of operations held by that statement in the  
17 OPERATION ID entity 74 is returned for consideration for possible execution. If there is  
18 no CL entity for an operation, all operations identified as destination operations in the  
19 OPERATIONS LINK entity will be considered for possible execution.

20 An optional entity in transaction DAG structure 50 is the BROADCAST entity  
21 62. The presence of BROADCAST entity 62 indicates that the operation is a broadcast

operation and should be sent to more than one service application for processing. The optional subsections place success criteria on the broadcast operation to determine when to advance the operation as a whole. If RESPONSE entity 68 is present, a data value indicates that there are a minimum number of successful responses expected before this operation may be advanced. If EXPRESSION entity 70 is present, it specifies that an action should be performed and a value returned and evaluated before this operation may be advanced. An expression can be a simple value, a math operation, the value of a variable, or the return value of a function.

**b. An illustrated implementation of a Transaction DAG.**

In an illustrated embodiment of the present invention, the transaction DAG data structure has the structure of the document type definition (DTD) shown in Table 1 and illustrated in FIG. 6 and FIG. 7. The INPUT entity 60, CONDITIONAL LOGIC entity 58 and OPERATION LINK(S) entity 56 of FIG. 5 are referred to as JOIN section 87, SPLIT section 86, and OPLINK section 85, respectively, in Table 1 and in FIG. 6 and FIG. 7.

TABLE 1

```

<!DOCTYPE CXTXDAG [
<!ELEMENT CXTXDAG (TRANSACTION)*>
<!ATTLIST CXTXDAG
    NAME CDATA #REQUIRED
    VERSION (1.0 | 2.0 | ...) \"1.0\"
    OBJMODEL (ECXpert | ...) \"ECXpert\"
>
<!ELEMENT TRANSACTION (OPERATION)*>
<!ATTLIST TRANSACTION
    NAME CDATA #REQUIRED
    TIMEOUT CDATA #IMPLIED
    SAVE CDATA #IMPLIED
>

```

```

<!ELEMENT OPERATION      (OPLINK* | SPLIT | JOIN) >
<!--ATTLIST OPERATION
      OPID      CDATA      #REQUIRED
      NAME      CDATA      #REQUIRED
      CXCNAM    CDATA      #REQUIRED
      BROADCAST CDATA      #IMPLIED
      TIMEOUT   CDATA      #IMPLIED
-->
<!--ELEMENT OPLINK      EMPTY>
<!--ATTLIST OPLINK
      SRCOPID   CDATA      #REQUIRED
      DSTOPID   CDATA      #REQUIRED
-->
<!--ELEMENT SPLIT      (STMT) *>
<!--ATTLIST SPLIT
      NAME      CDATA      #REQUIRED
-->
<!--ELEMENT STMT      (EXPR, OPID+) *>
<!--ATTLIST STMT
      NAME      CDATA      #REQUIRED
-->
<!--ELEMENT EXPR      (VALUE | OPERATOR | VAR |
                        FUNCTION) *>
<!--ATTLIST EXPR
      NAME      CDATA      #REQUIRED
-->
<!--ELEMENT OPID      EMPTY>
<!--ATTLIST OPID
      ID        CDATA      #REQUIRED
-->
<!--ELEMENT OPERATOR  (VALUE | OPERATOR | VAR |
                        FUNCTION) *>
<!--ATTLIST OPERATOR
      MATHOP     CDATA      #REQUIRED
-->
<!--ELEMENT VAR      EMPTY>
<!--ATTLIST VAR
      VARNAME    CDATA      #REQUIRED
      VALTYPE    CDATA      #IMPLIED
      OPID       CDATA      #IMPLIED
      INPUTDOC   CDATA      #IMPLIED
-->
<!--ELEMENT VALUE      EMPTY>
<!--ATTLIST VALUE
      STRVALUE   CDATA      #IMPLIED
      NUMVALUE   CDATA      #IMPLIED
-->
<!--ELEMENT FUNCTION  EMPTY>
<!--ATTLIST FUNCTION
      LIBNAME    CDATA      #REQUIRED
      FUNCNAME   CDATA      #REQUIRED
      VALTYPE    CDATA      #IMPLIED

```

```

>
<!ELEMENT JOIN      (FUNCTION | ARG*) >
<!ELEMENT ARG       (EXPR) >
<!ATTLIST ARG
    VARNAME    CDATA      #REQUIRED
    VALTYPE    CDATA      #IMPLIED
>
] >

```

**c. Designing a transaction and specifying an operation.**

TRANSACTION section 84 is composed of one or more operations that are to be executed in the order specified under the conditions provided at each juncture. At the transaction level, the designer must provide a NAME for the transaction that must be unique across all transactions that are defined within the domain of CX server 10. The name of the transaction is used for instantiating run-time transactions of this type as the result of a Transaction Request Message 284 (FIG. 2). Optionally, the user may provide a TIMEOUT value for the transaction. If specified, this represents the maximum amount of time, in seconds, that a transaction has to complete execution once it has been started. If no value is provided, or a value of zero is provided, no timeout is assumed and the transaction may take as long as necessary to complete. The user defining the transaction definition may also optionally use the SAVE tag to specify whether or not to save transactions of this type to a data base of transactions (also referred to as the persistence server.) A value of YES for this field indicates that transactions of this type should be saved. If not specified, the default turns saving ON for this transaction type.

Examples of portions of transaction definitions are provided to illustrate how the transaction DAG structure is used. Example 1 defines a transaction whose name is

“myTransaction” whose run-time instances should not be saved and can take at most 60 seconds to execute.

Example 1:

```
<TRANSACTION NAME="myTransaction" SAVE="NO" TIMEOUT="60">  
<!-- Define operations here -->  
</TRANSACTION>
```

Example 2 defines a transaction whose name is “anotherTransaction” whose run-time instances should be saved and has no maximum execution time restrictions.

Example 2:

```
<TRANSACTION NAME="anotherTransaction">  
<!--Define operations here -->  
</TRANSACTION>
```

TRANSACTION section 84 points to OPERATION section 86. Each operation must specify a NAME, OPID, and CXCNAME, and optionally a TIMEOUT value. The name specifies the logical name of the operation, and will often correspond to the service application (CXC) that executes it. There are two reserved names for two required operations known as CXtsHeadOp and CXtsTailOp. Every transaction must have a CXtsHeadOp and a CXtsTailOp; the CXtsHeadOp is always the first operation in a transaction, and the CXtsTailOp is always the last. These operations are in addition to any operations that are to be included in the transaction. The OPID is a numeric value that must be unique within the transaction definition; no other operation within the transaction may have the same OPID value. The CXCNAME specifies the logical name of the CXC (service application) that can execute this operation. When the CXCNAME indicates a value of '\*', any CXC which has registered with CX server 10 as being capable

of executing this type of operation may be used. An operation may optionally specify a TIMEOUT value. If specified, this defines the maximum amount of time an operation can take to execute. If no value is provided, or a value of zero is provided, no timeout is assumed and the operation can take as long as necessary to complete. Table 2 provides additional information about each of the data entities in the Transaction and Operation sections of the DAG data structure.

TABLE 2: Transaction and Operation Sections

Section Name	Tag Name	Required	Type	Default Value
TRANS-ACTION	<b>Meaning:</b> A transaction is a sequence of operations that are to be executed in a defined order under the given conditions.			
	NAME	Yes	Character	None
	<b>Meaning:</b> The name of the transaction. It will be used to refer to the type of transaction for instantiating run-time transactions of this type as the result of a Transaction Request Message. This name must be unique across all defined transactions.			
	TIMEOUT	No	Numeric	Zero
OPERATION	<b>Meaning:</b> The maximum amount of time the transaction can take to execute, in seconds. If this tag is not present or the value is 0, this means there is no timeout value.			
	SAVE	No	Character	YES
	<b>Meaning:</b> A flag which indicates whether or not to save transactions of this type to the persistence server. If present, any value other than 'YES' or 'yes' will turn saving off for run-time instances of transactions of this type. If not specified, a value of 'YES' is assumed.			
	<b>Meaning:</b> An operation is a request to perform some action. The operation's operation request document is prepared according to the definition provided in the JOIN section. This operation request document is sent to the indicated CXC for an operation request. The resulting message from the CXC is stored as the operation response document.			
	NAME	Yes	Character	None
	<b>Meaning:</b> The name of the operation. This does not have to be unique across the transaction. It refers to the logical name given to this type of operation. There are two pre-defined operation names that must appear in every transaction definition: 'CXtsHeadOp' refers to the first operation in the transaction; 'CXtsTailOp' refers to the last operation in the transaction.			

OPID	Yes	Numeric	None
<b>Meaning:</b> A numeric value assigned to this particular operation. It must be unique within the transaction definition.			
CXCNAME	Yes	Character	None
<b>Meaning:</b> The name of the CXC which can execute this operation. If the value is an asterisk (*), then the CX will, at run-time, determine the CXC's which can execute this operation (this is often used for broadcast operations). If a specific name is provided, the CX will look for a CXC instance with that name and attempt to have that CXC execute this operation.			
TIMEOUT	No	Numeric	Zero
<b>Meaning:</b> The maximum time, in seconds, the operation has to complete execution. If no value is provided, or a value of zero is provided, no timeout is assumed.			

1 Example 3 defines a simple operation whose name is “myOperation”, has an ID of “1”  
2 which can be executed by the service application, “myCXC”, and can take at most 60  
3 seconds to execute.

4 Example 3:

5           <OPERATION NAME="myOperation" OPID="1" CXCNAME="myCXC"  
6           TIMEOUT="60" />

7 Example 4 defines an operation whose name is “anotherOperation”, has an ID of “3”,  
8 whose CXC should be determined by the CX for each run-time instance, and has no  
9 restrictions on the amount of time it can take to execute.

10 Example 4:

11           <OPERATION NAME="anotherOperation" OPID="3" CXCNAME="\*" />

12           OPERATION section 86 points to OPLINK section 85. A link between two  
13 operations is specified using an OPLINK section. Each OPLINK section includes a  
14 single SRCOPID tag and DSTOPID tag. There can be 1 – n OPLINK sections per  
15 operation. The SRCOPID tag is the operation ID of the operation where the link starts,

1 and the DSTOPID tag is the operation ID of the operation where the link ends. Although  
2 not required, it is good practice to have the SRCOPID match the OPID of the  
3 OPERATION section that contains the OPLINK section.

4       Operation links define the order of execution of the operations. When one  
5 operation completes its execution, the operation links specify the set of operations that  
6 may be executed as a result. An operation is ready for execution when all other  
7 operations that have forward links to this operation have completed execution. Note that  
8 this includes operations that are considered complete for any reason, including timeout,  
9 failure, or elimination due to split condition logic. If a split condition is specified, the  
10 conditions defined by that split condition must be evaluated to determine which of the  
11 links to follow. For more details see the section below entitled Specifying conditional  
12 operation flow (SPLIT) logic. When defining a transaction, the first set of operations that  
13 should be executed must be linked as destination operations from the CXtsHeadOp  
14 operation. The final set of operations must all have CXtsTailOp as their destination  
15 operations in their operation links. The OPID of the CXtsHeadOp conventionally has a  
16 value of zero, although this is not mandatory. Table 3 provides additional information  
17 about each of the data entities in the OPLINK section of the DAG data structure.



TABLE 3: OPLINK Section

Section Name	Tag Name	Required	Type	Default Value
OPLINK	<b>Meaning:</b> Defines a link between the named operations. Whenever the operation identified as the source operation completes, the operation identified as the destination operation is considered for possible execution.			
	SRCOPID	Yes	Numeric	None
	<b>Meaning:</b> The source operation in the link. The value should correspond to the OPID specified in the OPERATION section..			
	DSTOPID	Yes	Numeric	None
	<b>Meaning:</b> The destination operation in the link. This value must correspond to the OPID specified in the OPERATION section of the operation that is the desired destination operation.			

Example 5 defines a simple linear transaction graph with three operations, Parse, Translate, and Gateway which are to be executed one after the other. In this example, the Parse operation has an ID of 1, the Translate operation has an ID of 2, and the Gateway operation has an ID of 3.

Example 5:

```

<OPERATION NAME="CXtsHeadOp" OPID="0" CXCNAME="Head">
<OPLINK SRCOPID="0" DSTOPID="1" />
</OPERATION>
<OPERATION NAME="Parse" OPID="1" CXCNAME="Parse">
<OPLINK SRCOPID="1" DSTOPID="2" />
</OPERATION>
<OPERATION NAME="Translate" OPID="2" CXCNAME="Translate">
<OPLINK SRCOPID="2" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="Gateway" OPID="3" CXCNAME="Gateway">
<OPLINK SRCOPID="3" DSTOPID="4" />
</OPERATION>
<OPERATION NAME="CXtsTailOp" OPID="4" CXCNAME="Tail">
</OPERATION>

```

Example 6 defines a transaction graph with concurrent operations where the first two operations are executed concurrently, followed by a third operation that is executed after those two complete.

Example 6:

```
<OPERATION NAME="CXtsHeadOp" OPID="0" CXCNAME="Head">
<OPLINK SRCOPID="0" DSTOPID="1" />
<OPLINK SRCOPID="0" DSTOPID="2" />
</OPERATION>
<OPERATION NAME="OP1A" OPID="1" CXCNAME="OP1ACXC">
<OPLINK SRCOPID="1" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="OP1B" OPID="2" CXCNAME="OP1BCXC">
<OPLINK SRCOPID="2" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="OP3" OPID="3" CXCNAME="OP3CXC">
<OPLINK SRCOPID="3" DSTOPID="4" />
</OPERATION>
<OPERATION NAME="CXtsTailOp" OPID="4" CXCNAME="Tail">
</OPERATION>
```

An operation may be specified as having up to three additional optional components. The operation may be defined as a Broadcast Operation, a set of Split conditions may be specified, and the method of preparing the operation request document to the operation, via a JOIN section, may be defined. Each of these is described in more detail below.

**d. Specifying conditional operation flow (SPLIT) logic.**

SPLIT section 86 is used whenever the decision about the next set of operations to execute depends upon some condition. SPLIT section 86 provides the conditional logic on which to base the decision about the operation(s) to consider for execution next, when the operation to which the SPLIT belongs completes execution. SPLIT section 86 is comprised of a set of STMT sections 90 (statement) which contain expressions to be evaluated. Within each STMT section is an expression section (EXPR) 94 and a set of operation ID sections 93 (OPID). An expression is some condition to evaluate; details about specifying an expression are provided in section g. below. The set of operation ID

sections 93 indicate those operations that should be slated for execution if the condition specified by the expression evaluates to a true value (a non-zero value). The operation IDs specified in the STMT sections must match one of the operation IDs in the set of operation links (OPLINK) for the operation containing the split condition. If there is no SPLIT section for an operation, all operations identified as destination operations in the OPLINK section will be considered for possible execution. Table 4 provides additional information about each of the data entities in SPLIT section 86 of the DAG data structure.

TABLE 4: SPLIT Section

Section Name	Tag Name	Required	Type	Default Value
SPLIT	<b>Meaning:</b> The SPLIT is used to decide which operations to consider for execution whenever the operation to which the SPLIT belongs completes execution. It is comprised of a series of statements (STMT) which are evaluated. For each statement that evaluates to a true condition, the list of operations held by that statement is returned for consideration for possible execution. If there is no SPLIT section for an operation, all operations identified as destination operations in the OPLINK section will be considered for possible execution. Any operation listed as part of a statement must also have been listed as a DSTOPIID in an OPLINK for the OPERATION where the SPLIT is defined.			
STMT	<b>Meaning:</b> A required subsection of a SPLIT section. It consists of an expression (EXPR) to be evaluated and a set of operation ID (OPID) sections listing the IDs of the operations to return if the expression evaluates to true.			
OPID	<b>Meaning:</b> Holds the ID tag to indicate the ID of an operation to be returned if an expression evaluates to true in a split statement.			
	ID	Yes	Numeric	None
	<b>Meaning:</b> The ID of the operation to be returned if the expression in a split statement evaluates to true..			

Example 7 defines a split condition in which the next operation should be executed only if the variable PROCEED is included in the output section of this operation's operation response document. (More information about the EXPR section is provided below.)

Example 7:

```
<OPERATION NAME="MYOP" OPID="1" CXCNAME="MYOPCXC">
<OPLINK SRCOPID="1" DSTOPID="2" />
<SPLIT>
<STMT>
<EXPR>
<VAR VALTYPE="NUMVALUE" VARNAME="PROCEED" OPID="1"
OPVARIOTYPE="OUTPUT"
OPDOCIOTYPE="OUTPUT" />
</EXPR>
<OPID ID="2" />
</STMT>
</SPLIT>
</OPERATION>
<OPERATION NAME="ANOTHEROP" OPID="2" CXCNAME="ANOTHERCXC">
</OPERATION>
```

**e. Specifying input arguments using the JOIN section.**

JOIN section 87 is used to build the input arguments for operation request message 286 (FIG. 2) for the operation to which this JOIN logic belongs. JOIN processing is essentially the translation of one or more documents into the operation request document. The join may be defined to map entire documents (or specific sections) of one or more operations into the operation request document or specific variables. The join may specify that only the input sections be mapped, that only the output section be mapped, or that both the input and output sections be mapped.

All operations considered for execution will have their JOIN section executed to build the operation request document. If the JOIN fails, the operation will not be executed. If no JOIN is provided for a particular operation (i.e., no input arguments are

specified), the default JOIN will consolidate the operation response documents 290 (FIG. 2) of all of the preceding operations that belong to this transaction into the operation request document for this operation. In particular, the default join maps all of the input and output variables of the previous operation(s) into the input and output sections of the operation request document for this operation. As previously noted, default behavior is implementation specific, and the Transaction DAG does not enforce this logic.

A join may be comprised of a series of argument sections (ARG) which specify the value to be given to one or more specific named variables in the operation request document of the operation. The ARG section consists of a series of tags defining the properties of the variable(s) in the operation request document and either an expression or document mapping to give the variable its value. Each variable is given a name (NAME) and a representation type (VALTYPE) along with an optional tag indicating if this variable is mandatory or optional (OPTIONAL). If no OPTIONAL tag is provided, or the value of the OPTIONAL tag is "NO" (or "no"), the variable is considered mandatory. If the OPTIONAL tag is present and its value is either "YES" (or "yes"), the variable is considered optional. This is used to determine how to proceed if the named variable cannot be given a value. If an optional variable is not available, the join can still succeed, provided that any other mandatory variables are available. If a mandatory variable is not available, the join is considered to have failed and the operation cannot be executed. Failure of the operation may, in turn, cause the entire transaction to fail. The variables may be given values based on the evaluation of some expression (EXPR) or from a mapped document, or specific section of a document.

When a function is to be executed, a user who defines a transaction may specify the JOIN translation in one of several ways. A user may define a dynamic library (DLL) and an entry point; the library is then loaded by CX server 10 and executed. The output of the entry point would be a single document. A user may alternatively provide Java classes for translation purposes, or may define a shell script mechanism. The shell script would get current documents as files and return the expected document in a location expected by CX server 10. Simple document translations may also be defined visually using a user interface mechanism for defining transactions. See Section 5.b. below for additional information about the user interface. Table 5 provides additional information about each of the data entities in JOIN section 87 of the DAG data structure.

TABLE 5: JOIN Section

Section Name	Tag Name	Required	Type	Default Value
JOIN	<b>Meaning:</b> The JOIN is used to build the input arguments for an operation request message for the operation to which this join belongs. All operations considered for execution will have their JOIN section executed to build the operation request document. If the JOIN fails, the operation will not be executed. If no JOIN is provided, the default JOIN will consolidate all of the preceding operations' operation response documents into the operation request document for the operation.			
	DOCVAR-TYPE	No	Character	DOC
DOC-VAR	<b>Meaning:</b> If present in the join, it defines whether the input section (INPUT), output section (OUTPUT), or both sections (DOC) of the documents are to be mapped to the operation request document for the join. This is used for joins where all of the previous operations' documents are to be merged to form the operation request document for the operation to which the join belongs.			
	<b>Meaning:</b> Defines how the identified XML document should be mapped to the indicated argument (ARG). It defines the operation that contains the document, which of its two documents to use, and the relevant section(s) of the document to extract..			
	OPID	Yes	Numeric	None
	<b>Meaning:</b> The ID of the operation whose document is to be extracted.			

OPDOCIOTYPE	No	Character	INPUT
<b>Meaning:</b> Defines whether the operation request document (INPUT) or operation response document (OUTPUT) should be extracted.			
DOCVAR-TYPE	No	Character	DOC
<b>Meaning:</b> Defines whether the input section (INPUT), output section (OUTPUT), or both sections (DOC) should be extracted.			
ARG			
<b>Meaning:</b> An argument to add to the operation request document for this operation. It specifies the name and type of the argument along with a tag indicating if it is required or optional. The associated EXPR defines how to derive the value for this argument.			
VARNAME	Yes	Character	None
<b>Meaning:</b> The name of the variable that will be added to the indicated section of the operation request document of this operation. Its value is determined by the expression associated with the argument.			
VALTYPE	No	Character	NUMVALUE
<b>Meaning:</b> . The representation of the value. It can be either 'NUMVALUE' for numeric values, 'STRVALUE' for string values, or 'DOCVALUE' for document values.			
OPTIONAL	No	Character	None
<b>Meaning:</b> If present, it indicates if the JOIN argument is required to be in the operation request document or not. If it is not present, it defaults to being required. If a required argument is not present, the JOIN will fail. If an optional argument is not present, the JOIN will proceed.			

Example 7 defines a default join for an operation (OPID = 3) which consolidates all of the variables in the preceding operations' operation response documents. In this example, two operations directly precede this operation (OPID = 1 and OPID = 2), and all of the variables in the operation response document for OPID = 1 and OPID = 2 would be mapped into the operation request document for OPID = 3.

Example 7:

```

<OPERATION NAME="myOP1" OPID="1" CXCNAME="myOPCXC">
<OPLINK SRCOPID="1" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="anotherOP" OPID="2" CXCNAME="anotherOPCXC">
<OPLINK SRCOPID="2" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="thirdOP" OPID="3" CXCNAME="thirdOPCXC">
</OPERATION>

```

Example 8 defines a join that maps the input variables of the previous operations to this operation's operation request document. In this example, only the variables in the INPUT section of the preceding operations' operation response document are mapped. The OUTPUT variables would not be mapped.

Example 8:

```
<OPERATION NAME="myOP1" OPID="1" CXCNAME="myOPCXC">
<OPLINK SRCOPID="1" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="anotherOP" OPID="2" CXCNAME="anotherOPCXC">
<OPLINK SRCOPID="2" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="thirdOP" OPID="3" CXCNAME="thirdOPCXC">
<JOIN DOCVARTYPE="INPUTVARLIST">
</JOIN>
</OPERATION>
```

Example 9 defines a join that maps both the input and output variables of previous operations to this operation's operation request document. In this example, the variables in both the INPUT and OUTPUT sections of the preceding operations' operation response documents are mapped.

Example 9:

```
<OPERATION NAME="myOP1" OPID="1" CXCNAME="myOPCXC">
<OPLINK SRCOPID="1" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="anotherOP" OPID="2" CXCNAME="anotherOPCXC">
<OPLINK SRCOPID="2" DSTOPID="3" />
</OPERATION>
<OPERATION NAME="thirdOP" OPID="3" CXCNAME="thirdCXC">
<JOIN DOCVARTYPE="VARLIST">
</JOIN>
</OPERATION>
```

Example 10 defines a join that maps the variables PRICE and QUANTITY from the operation response document of the operation with an ID of 2 to the input variable



1 TOTAL where TOTAL = PRICE \* QUANTITY. All of the variables are numeric. The  
2 variable, TOTAL, is mandatory.

3 Example 10:

```
4         <OPERATION NAME="MYOP" OPID="2" CXCNAME="MYCXC">  
5         <JOIN>  
6         <ARG VARNAME="TOTAL" VALTYPE="NUMVALUE">  
7         <EXPR>  
8         <OPERATOR MATHOP="SUM">  
9         <VAR VALTYPE="NUMVALUE" VARNAME="PRICE" OPID="2" />  
10        <VAR VALTYPE="NUMVALUE" VARNAME="QUANTITY" OPID="2" />  
11        </EXPR>  
12        </ARG>  
13        </JOIN>  
14        </OPERATION>
```

15 Example 11 defines a join that maps a previous operation's operation response document  
16 (OPID = 1) as a variable named "OP1OutputDoc." This variable is considered optional.

17 Example 11:

```
18        <OPERATION NAME="MYOP" OPID="2" CXCNAME="MYCXC">  
19        <JOIN>  
20        <ARG VARNAME="OP1OutputDoc" VALTYPE="DOC" OPTIONAL="YES">  
21        <DOCVAR OPID="1" OPDOCIOTYPE="OUTPUT" DOCVARTYPE="DOC" />  
22        </ARG>  
23        </JOIN>  
24        </OPERATION>
```

25 Example 12 defines a join that maps the minimum value of a variable, PRICE, from the  
26 operation response documents from a broadcast operation (OPID = 1) as a variable,  
27 LowestPrice. This variable is considered mandatory.

28 Example 12:

```
29        <OPERATION NAME="MYOP" OPID="2" CXCNAME="MYCXC">  
30        <JOIN>  
31        <ARG VARNAME="LowestPrice" VALTYPE="NUMVALUE" OPTIONAL="NO">  
32        <EXPR>  
33        <VAR VALTYPE="NUMVALUE" VARNAME="PRICE" OPID="1"  
34        BCAST_MATHOP="MIN"/>  
35        </EXPR>  
36        </ARG>
```

1 </JOIN>  
2 </OPERATION>

3 **f. Specifying a broadcast operation.**

4 A broadcast operation is a special type of operation in which more than one  
5 instance of the operation is executed. The decision as to how many instances to execute  
6 is a run-time decision made by CX server 10 by sending operation requests to every CXC  
7 which has registered as capable of executing operations of this type. To specify an  
8 operation as a broadcast operation, a BROADCAST section 88 must be included. Within  
9 this BROADCAST section, the two optional subsections of RESPONSE 91 and EXPR 94  
10 may be provided.

11 If the RESPONSE section is present, the MIN tag specifies the minimum number  
12 of responses required to be received before advancing past this operation. If no  
13 RESPONSE section is defined, the default is that all operation requests sent on behalf of  
14 this broadcast operation must be received before the operation as a whole can be  
15 advanced.

16 If the EXPR section is present, this indicates an expression that must be evaluated  
17 against each response received to determine if it should be counted toward the minimum.  
18 If no EXPR section is present, all responses received will be counted toward the minimum  
19 (if a minimum is specified). See the section, Specifying an Expression, for more  
20 information about expressions. Table 6 provides additional information about each of the  
21 data entities in BROADCAST section 88 of the DAG data structure.

1

TABLE 6: BROADCAST Section

Section Name	Tag Name	Required	Type	Default Value
BROAD-CAST	<b>Meaning:</b> If present, indicates the operation is a broadcast operation. The optional subsections can place success criteria on the broadcast operation to determine when to advance the operation as a whole.			
RES-PONSE	<b>Meaning:</b> If present, indicates there is a minimum number of successful responses expected before this operation can be advanced.			
	MIN	Yes	Numeric	None
	<b>Meaning:</b> The minimum number of successful responses required for advancement. If present, the value must be greater than zero.			

2 Example 13 defines a broadcast operation where the number of requests is to be  
3 determined at run-time. The name of the operation is "myBroadcast" and its ID is 1.

4 Example 13:

```
5         <OPERATION NAME="myBroadcast" OPID="1" CXNAME="*">
6         <BROADCAST />
7         </OPERATION>
```

8 Example 14 defines a more complex broadcast operation where the minimum number of  
9 responses is 1 and the response should contain a variable, PRICE, with a value less than  
10 10 to be considered successful.

11 Example 14:

```
12         <OPERATION NAME="myBroadcast" OPID="1" CXNAME="*">
13         <BROADCAST>
14         <RESPONSE MIN="1" />
15         <EXPR>
16         <OPERATOR MATHOP="LT">
17         <VAR VALTYPE="NUMVALUE" VARNAME="PRICE" OPID="1"
18         OPVARIOTYPE="OUTPUT"
19         OPDOCIOTYPE="OUTPUT"/>
20         <VALUE NUMVALUE="10" />
21         </OPERATOR>
22         </EXPR>
23         </BROADCAST>
24         </OPERATION>
```

1     **g.     Specifying an expression.**

2             The EXPR section 94 is used for split conditions, for determining values for  
3 arguments in a JOIN, and for defining BROADCAST advance criteria. An expression  
4 may be a simple value (VALUE), an operation (OPERATOR), a function (FUNCTION),  
5 or the value of a specified variable (VAR). When an expression is a simple value,  
6 whenever the expression is evaluated, it always returns the configured value. The  
7 VALUE parameter of the EXPR section could be used to initialize some variable in an  
8 operation to a configured value. An expression may be defined as the value of a named  
9 variable using the VAR tag. Whenever the expression is evaluated, the value of the  
10 named variable is returned, or an error is returned if the variable could not be found.  
11 Using the VAR tag in an expression also requires the following additional information:  
12 the name (VARNAME) of the variable; the ID of the operation that contains the variable  
13 (OPID); the document that contains the variable (OPDOCIOTYPE); the section of that  
14 document that contains the variable (OPDOCVARTYPE); and the representation type of  
15 the value (VALTYPE).

16             An expression may be a math operation (OPERATOR) applied to one or more  
17 variables. Supported math operations include the most commonly used operations such  
18 as greater than, equal to, less than, plus, minus and multiplication. All of the math  
19 operations, with the exception of 'PLUS', can only be applied to numeric values  
20 (VALTYPE="NUMVALUE"). Note that math operations do not work on document  
21 values. An expression may also be defined to return the result of executing a named  
22 function. A function as an expression requires the name of the function (FUNCNAME),

1 the path and library where the function is defined (LIBNAME) and the type of value  
 2 returned by the function (VALTYPE). When evaluated, the EXPR section returns the  
 3 evaluation result, or an indication of an error if the expression could not be evaluated. An  
 4 error occurs if the desired variable or function is not available or the expression was not  
 5 correctly defined. Table 7 provides additional information about each of the data entities  
 6 in EXPR section 94 of the DAG data structure.

TABLE 7: EXPR Section

Section Name	Tag Name	Required	Type	Default Value
EXPR	<b>Meaning:</b> A specification to perform some action and return the value. An expression can be a simple value, a math operation, the value of a variable, or the return value of a function.			
VALUE	<b>Meaning:</b> The expression should return the specified value whenever it is evaluated.			
OPER- ATOR	NUMVALUE	Yes	Numeric	None
	<b>Meaning:</b> The actual value to be returned.			
	<b>Meaning:</b> An action to perform on the indicated variables. With the exception of 'PLUS', operators only apply to numeric values. PLUS can be used to concatenate two string values.			
	MATHOP	Yes	Character	None
	<b>Meaning:</b> The math operation to perform on the indicated variables. If there is one VAR section, the following operations are supported: MINUS (reverses the sign of the value) If there are exactly two VAR sections, the following math operations are supported: PLUS (addition), MINUS (subtraction or sign reversal), TIMES (multiplication), DIV (division), MOD (modulus), GT (greater than), GE (greater than or equal to), LT (less than), LE (less than or equal to), EQ (equivalence), AND (and two numbers), OR (or two numbers). If there are more than two VAR sections, the following operations are supported: MIN (return the minimum of all the values), MAX (return the maximum of all the values), AVG (return the average of all the values).			

VAR			
<b>Meaning:</b> Specifies a variable. It is used to identify a variable from an existing document.			
VALTYPE	No	Character	NUMVALUE
<b>Meaning:</b> The representation of the value. It can be either 'NUMVALUE' for numeric values, 'STRVALUE' for string values, or 'DOCVALUE' for document values.			
VARNAME	Yes	Character	None
<b>Meaning:</b> The name of the variable to locate.			
OPID	No	Numeric	None
<b>Meaning:</b> The ID of the operation which contains the desired variable. If this tag is not present, the OPID defaults to a predetermined value.			
OPVARIOTYPE	No	Character	INPUT
<b>Meaning:</b> The location in the document where the variable is located. The default is 'INPUT' which indicates the variable is in the input section. The other possible value is 'OUTPUT' which indicates the variable is in the output section of the document.			
OPDOCIOTYPE	No	Character	INPUT
<b>Meaning:</b> The document that contains the desired variable. This can either be the operation request document (INPUT) or the operation response document (OUTPUT) of the indicated operation..			
BCAST_MATHOP	No	Character	None
<b>Meaning:</b> This must be specified if the operation identified by OPID is a broadcast operation. It indicates how to treat the values held by each broadcast instance. Since only one value can be mapped to a variable, this describes the math operation to perform to determine that value. The supported operations are SUM (to add up all of the values), MIN (to return the minimum of all the values), MAX (to return the maximum of all the values), and AVG (to return the average of all the values)..			
FUNC-TION			
<b>Meaning:</b> If present, indicates an external function should be executed for this expression.			
LIBNAME	Yes	Character	None
<b>Meaning:</b> The path and name of the library which contains the desired function.			
FUNCNAME	Yes	Character	None
<b>Meaning:</b> The name of the function to execute.			
VALTYPE	No	Character	NUMVALUE
<b>Meaning:</b> The type of value returned by the function. It can be either 'NUMVALUE' for numeric values, 'STRVALUE' for string values, or 'DOCVALUE' for document values.			

Example 15 defines an expression that always returns the value of 10.

Example 15:

```
<EXPR>  
<VALUE NUMVALUE="10" />  
</EXPR>
```

Example 16 defines an expression in which two numbers are added together from the input section of the operation request document of the operation whose OPID is 1.

Example 16:

```
<EXPR>  
<OPERATOR MATHOP="PLUS">  
<VAR VALTYPE="NUMVALUE" VARNAME="VAR1" OPID="1" />  
<VAR VALTYPE="NUMVALUE" VARNAME="VAR2" OPID="1" />  
</OPERATOR>  
</EXPR>
```

Example 17 defines an expression as a function called "myFunc" which is found in the library at location "/usr/local/lib/myLib.so" and returns a numeric value.

Example 17:

```
<EXPR>  
<FUNCTION FUNCNAME="myFunc"  
LIBNAME="/usr/local/lib/myLib.so"  
VALTYPE="NUMVALUE" />  
</EXPR>
```

#### 4. Operation of the Transaction Service.

The general functions of transaction processing service 200 of FIG. 2 are illustrated in the flowchart of FIG. 8. These functions are described below with reference to the components shown in FIG. 2. CX server 10 receives messages from requesting applications and service applications. CX server 10, after handling message protocol functions, passes these received messages to transaction service 200 in box 202. CX server 10 uses transaction service 200 to track a transaction thread, to traverse transaction

1 logic and to perform transaction execution. Transaction service 200 provides a set of  
2 service interfaces with conditionals and mapping of DOM objects for working with the  
3 transaction logic. The service interfaces include those shown in Table 8.

TABLE 8

API	Function
CreateTransaction	creates a transaction instance
StartTransaction	starts execution of a transaction instance
EndTransaction	ends execution of a transaction instance
AdvanceTransaction	advances a transaction instance by executing a next list of operations
GetTransaction	gets a transaction object
RetryTransaction	retries or re-executes selected transaction operations
RestartTransaction	restart from the beginning the selected transaction
SuspendTransaction	halt execution of an active transaction
ResumeTransaction	resume execution of an active transaction
AbortTransaction	Halt, permanently, execution of an active transaction
GetInputMsg	gets the input XML document of a transaction or operation
GetOutputMsg	gets the output XML document of a transaction or operation

5 As shown in FIG. 2, transaction service 200 handles four types of messages; it  
6 may receive transaction request messages 284 and operation response messages 290, and  
7 it may send operation request messages 286 and transaction response messages 294.

8 Transaction service 200 first determines what kind of message has been received  
9 in the query boxes 204 and 206. If the message is neither one, control passes to a  
10 message error handling procedure 250 and processing control returns to CX server 10. If



1 the message is a transaction request message 284, this is a new transaction, and control  
2 passes from box 204 to box 210, where transaction service 200 calls the  
3 StartTransaction interface to create a new transaction instance associated with a  
4 unique identifier, referred to as the transaction ID, and to start transaction execution.  
5 Creating a new transaction includes calling CreateTransaction to retrieve the  
6 transaction definition 282 that matches the transaction name in request message 284 from  
7 transaction definition database 296, and producing the directed acyclic graph that  
8 represents the transaction instance. Transaction service 200 then begins traversing the  
9 transaction instance graph by obtaining a list of operations for execution, in box 214,  
10 using the SPLIT logic of the head operation. For each operation in the operation list,  
11 transaction service 200 calls GetInputMSG to create the input document(s) for the  
12 operation, in box 230, using the information specified in the JOIN section for the  
13 operation, and produces the operation request document 286, in box 234. For each  
14 operation, transaction service determines the service application name of the service  
15 application that is to perform the operation, using the CXCNAME tag. Then, transaction  
16 service 200 returns the operation request document(s) CX server 10 for sending to their  
17 respective service applications, in box 260, and control returns to CX server 10.

18 If the incoming message is not a transaction request, as determined in box 204,  
19 transaction service 200 queries whether it is an operation response 286 received from a  
20 service application, in box 206. If the message is an operation response, transaction  
21 service 200 updates the transaction state. Each operation response message contains the

1 transaction ID, the operation name and the output results produced by the service  
2 application, and is stored in a data store for later access and processing. The transaction  
3 state changes every time an operation response message is received.

4 Transaction service 200 then determines, in box 216, whether the operation  
5 response message is in response to a broadcast operation. A broadcast operation may  
6 involve invoking more than one service application to perform the operation. In the  
7 illustrated implementation of transaction service 200, the criteria for advancing to a next  
8 operation node is to wait until all responses to operations associated with the node are  
9 received. To determine whether a broadcast operation is completed, the RESPONSE,  
10 MIN and EXPR tags are used to determine how to process operation response messages.  
11 As noted earlier, if the RESPONSE section is present, the MIN tag specifies the minimum  
12 number of responses required to be received before advancing past this operation. If no  
13 RESPONSE section is defined, the default is that all operation requests sent on behalf of  
14 this broadcast operation must be received before the operation as a whole can be  
15 advanced. If the EXPR section is present, this indicates an expression that must be  
16 evaluated against each response received to determine if it should be counted toward the  
17 minimum. If no EXPR section is present, all responses received will be counted toward  
18 the minimum, if a minimum has been specified. Collectively these rules may be referred  
19 to as the *broadcast advance criteria*. If the query in box 216 determines that this  
20 operation response message is in response to a broadcast operation, then Transaction  
21 service 200, in box 218, queries whether the broadcast advance criteria have been met,

1 and if so, control proceeds to box 220 to advance the transaction. If broadcast advance  
2 criteria have not been met, then this operation node is not complete, the transaction  
3 cannot be advanced, and control is returned to CX server 10.

4 If the message is an operation response message and there is no pending broadcast  
5 operation, transaction service 200 calls AdvanceTransaction procedure in box 220.  
6 Transaction service 200 then calls GetTransaction to update the transaction  
7 instance's state information, and then evaluates the SPLIT logic of the operation  
8 associated with this operation response message to obtain the next list of operations from  
9 the transaction instance graph. Transaction service 200 queries, in box 224, whether  
10 there is a next operations list available. If a next list of operations is available, then CX  
11 server 10 still has more operations to perform for this transaction, and the transaction may  
12 be advanced to have the appropriate service application(s) perform the next operations.  
13 Transaction service 200 ensures that none of the operations in the list of next operations  
14 has a predecessor operation that is still pending and has not yet completed. Control  
15 passes to boxes 230, 234 and 260 where the next operation request message(s) are  
16 produced and sent out, as described above.

17 If the query in box 224 indicates that there is no next operations list, the  
18 transaction has been completed (assuming that the incoming message is not in error).  
19 This means that the operation response message just received is for an operation whose  
20 SPLIT logic or OPLINK section points to the required tail operation in the transaction  
21 instance. The tail operation node is available as the next operation in the next operation

1 list. Control then passes to boxes 240 and 244 where the transaction response message is  
2 created. The JOIN logic of the tail operation node contains the transaction response  
3 document format expected by the requesting (originating) application. Transaction  
4 service 200 calls GetOutputMSG to obtain the output document for the transaction,  
5 produces the transaction response message using this document format, identifies the  
6 requesting application and then sends the transaction response message to that application  
7 in box 260.

8 Transaction service 200 also supports transaction timer, purging, logging and  
9 recovery mechanisms that are not shown in FIG. 8. The timer mechanism allows  
10 transaction service 200 to discontinue processing of this transaction if operation  
11 responses are not received in a timely manner. When operation responses are not  
12 received after retries and a waiting period, the transaction instance is ended (i.e., removed  
13 from memory) and is marked as a timeout transaction in the data store of transactions.  
14 Creating a timer for each operation, if needed, is accomplished during  
15 AdvanceTransaction procedure 220. When transactions end, there is a purging  
16 mechanism to remove the transaction object from all transaction lists.

17 Transaction logging involves saving the transaction instance, sufficient run time  
18 information, and transaction state changes to enable transaction recovery if a first CX  
19 server 10 is no longer operational and a backup CX server assumes transaction  
20 processing. The following transaction data elements are saved during transaction  
21 logging: the transaction instance, the transaction request message, the transaction

1 response message (if any), and transaction attributes including the transaction ID, the  
2 transaction DAG name, transaction state information, the originating requesting  
3 application identifier and name. Operation information saved includes operation request  
4 messages, operation response messages, the operation identifier (OPID), operation state  
5 information, and broadcast operation information (e.g., number of service applications  
6 requested and number of operations pending). Executing CXCs are saved as well.  
7 Transaction recovery may be done at the individual transaction level or for all  
8 transactions started by CX server 10.

9 **5. Transaction tools.**

10 **a. Test transaction template.**

11 Table 9 provides a transaction that may be used as a template to test the interface  
12 between a service application (referred to as a CXC) and transaction service 200 of CX  
13 server 10. Transaction definition line <CXTXDAG NAME="TsGraph" identifies this  
14 XML document as containing a transaction definition. Transaction definition line  
15 <TRANSACTION NAME="TX-Template"> identifies the start of a transaction  
16 definition section for a transaction called "TX-Template". TX-Template is the name to  
17 be used in the transaction request document to request a transaction of this type to be  
18 executed. The template transaction is a simple linear transaction with a total of three  
19 operations identified by the OPID tag as operations 0, 1 and 2. The operations identified  
20 with OPID = 0 and OPID = 2 and having names "CxtsHeadOp" and  
21 "CxtsTailOp" indicate the head and tail operations, respectively, required in all

1 transactions. The transaction definition line <OPLINK SRCOPID="0"  
 2 DSTOPID="1" specifies that the operation having OPID = 1 is the destination  
 3 operation of the head operation, and so is the first "real" operation to be performed.  
 4 Thus, whenever a transaction request document is received requesting a transaction called  
 5 "TX-Template", the first operation to be executed is OPID = 1, which requests the  
 6 CXC being tested to perform its function. The transaction definition line  
 7 </OPERATION> indicates the end of an operation definition.

TABLE 9

```

<CXTXDAG NAME="TsGraph"
<TRANSACTION NAME="TX-Template"

<OPERATION OPID="0" NAME="CxtsHeadOp" CXCNAME="Head">
<OPLINK SRCOPID="0" DSTOPID="1" /
</OPERATION>

<!-- The operation below should be customized to the
CXC being tested. -->
<!-- The following must be specified in the OPERATION
section to complete this transaction definition: -->
<!-- * NAME - name of the operation. Typically, this
is the same as the name of your CXC; and -->
<!-- * CXCNAME of the CXC. This is the name of the
CXC being tested. -->
<OPERATION OPID="1" NAME="cxc-template-op-1"
CXCNAME="*">
<OPLINK SRCOPID="1" DSTOPID="2" />
<JOIN DOCVARTYPE="VARLIST"> </JOIN>
</OPERATION>

<OPERATION OPID="2" NAME="CXtsTailOp" CXCNAME="">
<JOIN DOCVARTYPE="VARLIST"></JOIN>
</OPERATION>
</TRANSACTION>
</CXTXDAG>

```

9 The operation definition for OPID = 1 further specifies the name of the  
 10 operation, "cxc-template-op-1", and the name of the CXC designated to perform

the operation. Typically, the NAME and CXCNAME fields will have the same value.

So, for example, if the CXC to be executed is named 'Parse', the line would read:

```
<OPERATION OPID="1" NAME="Parse" CXCNAME="Parse">
```

The JOIN tag identifies how this <JOIN> operation should build its operation request document. In this case, this type of join will map all of the variables in the data section of the transaction request document into the data section of the operation request document. For example, assume the transaction request document has the following data section:

```
<DATA>
<INPUT>
<FILENAME NAME="myTestFile.txt" />
<MAPNAME NAME="myMap.txt" />
</INPUT>
<OUTPUT> </OUTPUT>
</DATA>
```

Then, the data section of the operation request document would look like:

```
<DATA>
<INPUT>
<FILENAME NAME="myTestFile.txt" />
<MAPNAME NAME="myMap.txt" />
</INPUT>
<OUTPUT> </OUTPUT>
</DATA>
```

The operation request document for operation 1 is then sent to the CXC being tested. The transaction definition line <OPLINK SRCOPID="1" DSTOPID="2" specifies that the operation having OPID = 2 is the destination operation of operation 1, and so is to be performed after completion of operation 1.

A service application has access to a library of interfaces, referred to as the CXsdk, to interact with CX server 10. The interfaces enable a custom-built application to

1 include the application logic for the function of the CXC. The interfaces also provide for  
2 a service application to connect to CX server 10, to register itself as a CXC to sign up for  
3 an operation, and to send and receive messages. The CXsdk library also includes the  
4 XML parsing and constructing tools. The service CXC uses one of these interfaces to  
5 extract any needed variables from the operation request document it receives from CX  
6 server 10. The CXC then performs the function it has been configured to do. After  
7 completing its function, the CXC issues an operation response document, using the  
8 CXsdk, and sends that document back to CX server 10, and to operation 2, the tail  
9 operation, in the transaction graph of the TX-Template transaction.

10 The role of the tail operation is to build the transaction response document that is  
11 sent back to the CXC that requested the transaction providing information about the  
12 transaction that just executed. The join section for operation 2 identifies how to build the  
13 transaction response document. In this case, this type of join will map all of the variables  
14 in the data section of the operation response document from operation OPID = 1. CX  
15 server 10 then sends the transaction response document back to the requesting CXC.  
16 Finally, the transaction definition lines `</TRANSACTION>` and `</CXTXDAG>`  
17 respectively identify the end of the transaction definition for TX-Template, and the end of  
18 the XML document.

19 **b. Producing transaction definitions.**

20 A user interface application may be provided with CX server 10 for a user to  
21 design and specify a transaction definition. A user may construct a transaction visually



1 by selecting from among operations that are available, according to their descriptions.

2 The user interface may provide assistance to the user when specifying a unique identifier

3 for the transaction definition. In addition, the user must identify the input and output

4 DTD's of the transaction. The user interface may operate in one of two modes. The first

5 is simply as a data entry tool for capturing the transaction definition. The second mode of

6 operation allows for the user interface to validate the correctness of the definition

7 dynamically, by connecting to the CX server.

8 **6. The machine and software product of the invention.**

9 FIG. 9 is a block diagram of distributed network 140 that includes processor-

10 controlled machines 142, 144, 146 and 100. The component parts of machine 100 have

11 been enlarged to schematically illustrate a machine in which the present invention may be

12 used. Machine 100 is an example of a processor-controlled machine that may be used to

13 implement commerce exchange server 10 of FIG. 1 including transaction service 200

14 which utilizes the transaction DAG data structure of the present invention. Similarly, any

15 one of the processor-controlled machines 142, 144 and 146 may implement one of

16 machines 20, 22 or 24 of FIG. 1 that include a service application or one of machines 32

17 or 36 that include a client application of the commerce network illustrated in FIG. 1.

18 While the present invention may be used in any machine having the common

19 components, characteristics, and configuration of machine 100, the invention is not

20 inherently related to any particular processor, machine, system or other apparatus. The

21 machine or system may be specially constructed and optimized for the purpose of

22 carrying out the invention. Alternatively, machine 100 may comprise a general-purpose

1 computer selectively activated or reconfigured by a computer program stored in the  
2 computer. In still another alternative machine 100 may be a combination of a general-  
3 purpose computer and auxiliary special purpose hardware. When a machine such as  
4 machine 100 is suitably programmed to embody or make use of the present invention, the  
5 machine is not a standard or known configuration. In the claims, machine 100 is referred  
6 to as a “computer” for purposes of simplifying the claim language, but the term  
7 “computer” is intended to include any and all machines as described and shown in FIG. 9  
8 and is not intended to limit the scope of machine 100 in any way.

9 Machine 100 includes a bus or other internal communication means 101 for  
10 communicating information, and a processor 102 coupled to bus 101 for processing  
11 information. Machine 100 further comprises a random access memory (RAM) or other  
12 volatile storage device 104 (referred to as main memory), coupled to bus 101 for storing  
13 information and instructions to be executed by processor 102. Main memory 104 also  
14 may be used for storing temporary variables or other intermediate information during  
15 execution of instructions by processor 102. Machine 100 also comprises a read only  
16 memory (ROM) and/or static storage device 106 coupled to bus 101 for storing static  
17 information and instructions for processor 102, and a data mass storage access device 107  
18 such as a magnetic disk drive or optical disk drive. Data mass storage access device 107  
19 is coupled to bus 101 and is typically used with a computer readable mass storage  
20 medium 160, such as a magnetic or optical disk, for storage of information and  
21 instructions. Machine 100 may include more than one storage access device 107. For  
22 example, machine 100 may include both a storage access device for a non-removable

1 medium such as an internal magnetic (hard) disk and a mass storage access device for a  
2 removable medium such as an optical CD-ROM, a magnetic floppy disk, a PC-card, or  
3 magnetic tape.

4 Machine 100 may, but need not, include a conventional display device 121  
5 capable of presenting images, such as a cathode ray tube or a liquid crystal display (LCD)  
6 device or any other device suitable for presenting images. Display device 121 is coupled  
7 to bus 101 through bus 103 for displaying information to a computer user. An  
8 alphanumeric input device 122, including alphanumeric and other keys, may also be  
9 coupled to bus 101 through bus 103 for communicating information and command  
10 selections to processor 102. An additional user input device is cursor control device 123,  
11 such as a mouse, a trackball, stylus, electronic tablet, or cursor direction keys coupled to  
12 bus 101 through bus 103 for communicating direction information and command  
13 selections to processor 102, and for controlling cursor movement on display device 121.  
14 Another device which may optionally be coupled to bus 101 through bus 103 is a hard  
15 copy device 124 which may be used for printing instructions, data, or other information  
16 on a medium such as paper, film, or similar types of media. Note that the actual manner  
17 in which the physical components of machine 100 are connected may vary from that  
18 shown in FIG. 9. The manner of connection may include hardwired physical connections  
19 between some or all of the components, as well as connections over wired or wireless  
20 communications facilities, such as through remote or local communications networks and  
21 infrared and radio connections. Note further that not all of the components of machine  
22 100 shown in FIG. 9 may be required to carry out the functions of commerce exchange

1 server 10 or to make use of the transaction DAG data structure of the present invention.  
2 Those of ordinary skill in the art will appreciate that various configurations of machine  
3 100 may be used to carry out a particular implementation of commerce exchange server  
4 10 or the transaction DAG data structure. For example, machine 100 may be a  
5 Workgroup Enterprise server machine manufactured by Sun Microsystems, Inc. of  
6 Mountain View California that includes one or more Ultra SPARC™ processors, and that  
7 operates using the Solaris™ operating system.

8 Machine 100 further includes communication, or network interface, device 125,  
9 coupled to bus 101 through bus 103, for use in sending data to and receiving data from  
10 other nodes of distributed network system 140 according to standard network protocols.  
11 This communication device 125 may include any of a number of commercially available  
12 networking peripheral devices such as those used for coupling to an Ethernet, token ring,  
13 Internet, or wide area network.

14 Processor 102, together with an operating system, operates to execute instructions  
15 (e.g., program code) to produce and use data. The program code and data may reside in  
16 main memory (RAM) 104, in read only memory 106, on the non-removable hard disk  
17 storage accessed by storage access device 107, or even on another processor-controlled  
18 machine connected to network 140. The program code and data may also reside on a  
19 removable medium that is loaded or installed onto machine 100 when needed by means  
20 of a storage access device 107 suitable for that purpose. When program code (i.e.,  
21 software) implementing commerce exchange server 10 is stored in a memory device  
22 accessible to processor 102, machine 100 is configured to perform the functions of

1 commerce exchange server 10 of FIG. 1, and, in particular, to process transactions having  
2 the structured format illustrated in FIG. 5 or FIG. 6 and FIG. 7. An input transaction  
3 request message, such as transaction request message 284 of FIG. 2, is provided from  
4 communication device 125 and is forwarded via data bus 103 to bus 101 for storage in  
5 main memory 104 for later access by processor 102. Processor 102 executes program  
6 instructions, included in one of the above-described memory components, that implement  
7 operation 200 of FIG. 8. During execution of the instructions, processor 102 accesses  
8 memory 104 or 106 to obtain or store data necessary for performing its operations. For  
9 example, when machine 100 is configured to perform operation 500 of FIG. 8, processor  
10 102 may access transaction DTD 50 (FIG. 5) or transaction DTD 80 (FIG. 6 and FIG. 7)  
11 in memory 104 in order to perform the functions of transaction service 200 starting a new  
12 transaction instance.

13 FIG. 9 also shows software and data structure product 160, an article of  
14 manufacture that can be used in a machine that includes components like those shown in  
15 machine 100. Software and data structure product 160 includes data storage medium 170  
16 which stores instructions, also referred to as program code or computer readable code, for  
17 executing operations that process transactions as defined by the present invention, such as  
18 operation 200 of FIG. 8. Data storage medium 170 also stores one or more data  
19 structures, such as Transaction DAG 50 of FIG. 5 for use in producing transaction  
20 instances and executing transactions. As used herein, a "data storage medium" covers  
21 one or more distinct units of a medium that together store a body of data. Examples of  
22 data storage media include magnetic media such as floppy disks, diskettes, magnetic tape,

1 and PC cards (also previously known as PCMCIA memory cards), optical media such as  
2 CD-ROMs, and semiconductor media such as semiconductor ROMs and RAMs. By way  
3 of example, a set of magnetic disks or optical CD-ROMs storing a single body of data  
4 would be a data storage medium.

5 Software and data structure product 160 may be commercially available to a  
6 purchaser or user in several forms. In one typical form, software and data structure  
7 product 160 is commercially available in the form of a shrink-wrap package that includes  
8 data storage medium 170 and appropriate documentation describing the product. In that  
9 case, data storage medium 170, also referred to as a computer-readable medium, is a  
10 physical medium that stores one or more data structures or instruction data that is  
11 accessed by storage medium access device 107 or its equivalent. "Storage medium access  
12 device" is a device that can access data stored on a data storage medium. Storage  
13 medium access device 107 may be contained in a distinct physical device into which data  
14 storage medium 170 is inserted into, mounted on, or otherwise installed into, in order for  
15 the storage medium access device to access and retrieve the data stored thereon.  
16 Examples of storage medium access devices include disk drives, CD-ROM readers, and  
17 DVD devices. A storage medium access device may be physically separate from  
18 machine 100, or enclosed as part of a housing of machine 100 that includes other  
19 components. Mass storage device 107 may also be remotely located (not shown) as part  
20 of some other processor-controlled machine, such as a server, on network 140. Mass  
21 storage device 107 may provide instructions retrieved from medium 170 to processor 102  
22 via bus 101, causing processor 102, when executing the instructions, to process

1 transactions in accordance with the teachings herein. Mass storage device 107 may  
2 provide one or more data structures retrieved from medium 170 to processor 102 via bus  
3 101, for use in processing transactions in accordance with the teachings herein. If device  
4 107 is remotely located, program instructions and data structures are provided from  
5 storage medium 170 to processor 102 of machine 100 by way of communication device  
6 125 from network 140.

7 Software and data structure product 160 may also be commercially or otherwise  
8 available to a user in the form of a data stream indicating instruction data for processing  
9 transactions or one or more data structures for use in processing transactions in  
10 accordance with the teachings herein. The data stream is transmitted to the user over a  
11 communications facility from a remotely-located storage device. In this case, article 160  
12 is embodied in physical form as signals stored on the remotely-located storage device; the  
13 user accesses the contents of data storage medium 170 in order to purchase or otherwise  
14 obtain a copy of those contents, but typically does not purchase or acquire any rights in  
15 the actual remotely-located storage device. When software product 160 is provided in the  
16 form of a data stream transmitted to the user over a communications facility from the  
17 remotely-located storage device, instruction data and data structures stored on data  
18 storage medium 170 are accessible via communications device 125. Alternatively, a data  
19 stream transmitted to the user over a communications facility from the remotely-located  
20 storage device may be stored in some suitable local memory device of machine 100 or a  
21 data storage medium 107 locally accessible to processor 102 using bus 101.

FIG. 9 illustrates various examples of how data storage medium 170 may be configured. Software and data structure product 160 may include one or more of the types of data illustrated in FIG. 9. For example, data storage medium 170 may be configured with transaction definition data structure 280 of FIG. 2 and transaction DTD data structure 50 of FIG. 5 for use by transaction service 200 for producing a transaction instance DAG data structure and executing a transaction according to the process flow in FIG. 8. When implementing the specific illustrated embodiment of CX server 10 and transaction service 200 described herein, data storage medium 170 would be configured with transaction DAG data structure 80 of FIGS. 6 and 7.

Data storage medium 170 may also be configured with transaction service processing instruction data 162 for performing operation 200 (FIG. 8). FIG. 9 shows representative examples of the functional components of instruction data 162 such as advance transaction instructions 164 and start transaction instructions 166. The instruction data 162, 164 and 166 is provided to processor 102 for execution when transaction service processing is to be performed. For example, when instructions 162 are provided to processor 102, and processor 102 executes them, machine 100 is operated to perform the operations for starting or advancing a transaction, processing a broadcast transaction, producing operation request messages, or producing a transaction response message, according to operation 200 of FIG. 8. Note also that when software and data structure product 160 comprises the entire commerce exchange server application 10 of FIG. 1, data storage medium 170 may include additional instruction data (not shown) for carrying out operations 12, 14, 19 and 400 of CX server 10.



1           While the invention has been described in conjunction with one or more specific  
2   embodiments, this description is not intended to limit the invention in any way.  
3   Accordingly, the invention as described herein is intended to embrace all modifications  
4   and variations that are apparent to those skilled in the art and that fall within the scope of  
5   the appended claims.

**WHAT IS CLAIMED IS:**

1 1. An XML (extensible markup language) transaction definition document stored  
2 on a computer-readable medium comprising a plurality of operation data portions each  
3 defining an operation; the plurality of operations collectively defining a transaction;  
4 each operation data portion, when parsed by a process automation application, causing  
5 the process automation application to communicate with a service application program  
6 to perform the operation; at least one operation data portion comprising a conditional  
7 logic data portion; when parsed by the process automation application, the conditional  
8 logic data portion causing the process automation application to condition  
9 performance of a next operation on evaluation of operation response data from  
10 performing the operation.

1 2. The XML transaction definition document of claim 1 wherein the conditioning  
2 logic data portion indicates at least one of a mathematical expression, a function, and a  
3 variable data item; and wherein, when parsed by the process automation application,  
4 the conditioning logic data portion causes the process automation application to  
5 evaluate the at least one of the mathematical expression, the function, and the variable  
6 data item using the operation response data.

1 3. The XML transaction definition document of claim 1 wherein the XML  
2 transaction definition document is represented as a directed acyclic graph data  
3 structure; and wherein the plurality of operation data portions are represented as nodes  
4 in the directed acyclic graph.

1 4. The XML transaction definition document of claim 1 wherein the at least one  
2 operation data portion further comprises an input data portion including an input  
3 document identifier indicating a source XML document; the source XML document  
4 including input data for performing the operation.

1 5. The XML transaction definition document of claim 4 wherein the input  
2 document identifier indicates an XML output response document as the source XML  
3 document; the XML output response document being produced by a service  
4 application previously performing one of the plurality of operations collectively  
5 defining the transaction.

1 6. The XML transaction definition document of claim 1 wherein the at least one  
2 operation data portion further comprises an input data portion indicating argument  
3 input data for performing the operation; the argument input data including a variable  
4 name, an argument value, and an argument expression; the argument expression, when  
5 parsed and evaluated by the process automation application, producing the argument  
6 value.

1 7. The XML transaction definition document of claim 6 wherein the argument  
2 expression indicates at least one of a mathematical expression, a function, and a  
3 variable data item; and wherein, when parsed by the process automation application,  
4 the input data portion causes the process automation application to evaluate the at least  
5 one of the mathematical expression, the function, and the variable data item to produce  
6 the argument value.

1 8. An XML (extensible markup language) transaction definition document stored  
2 on a computer-readable medium comprising a plurality of operation data portions each  
3 defining an operation; the plurality of operations collectively defining a transaction;  
4 each operation data portion, when parsed by a process automation application, causing  
5 the process automation application to communicate with a service application program  
6 to perform the operation; at least one operation data portion indicating a broadcast  
7 operation and including a broadcast data portion; when parsed by the process  
8 automation application, the broadcast data portion causing the process automation  
9 application to communicate with a plurality of service applications to cause each  
10 service application to perform the operation.

1 9. The XML transaction definition document of claim 8 wherein the broadcast data  
2 portion includes a response data portion; when parsed by the process automation  
3 application, the response data portion causing the process automation application to  
4 evaluate operation response data received from the plurality of service applications to  
5 determine a success outcome or a failure outcome of the broadcast operation.

1 10. The XML transaction definition document of claim 9 wherein the response data  
2 portion indicates a minimum response value indicating a minimum number of required  
3 responses from service applications performing the operation; when parsed by the  
4 process automation application, the response data portion causing the process  
5 automation application to determine whether the minimum number of required  
6 responses were received from the plurality of service applications.

1 11. The XML transaction definition document of claim 9 wherein the broadcast data  
2 portion further includes an expression data portion indicating at least one of a  
3 mathematical expression, a function, and a variable data item; when parsed by the  
4 process automation application, the expression data portion causing the process  
5 automation application to evaluate the at least one of the mathematical expression, the  
6 function, and the variable data item using the operation response data to determine the  
7 success or failure outcome of the broadcast operation.

1 12. The XML transaction definition document of claim 8 wherein the XML  
2 transaction definition document is represented as a directed acyclic graph data  
3 structure; and wherein the plurality of operation data portions are represented as nodes  
4 in the directed acyclic graph.

1 13. A transaction definition data structure stored on a computer-readable medium  
2 comprising a plurality of operation data portions indicating a plurality of operations  
3 collectively defining a transaction; each operation data portion defining an operation  
4 and comprising:  
5 an operation identifier uniquely identifying the operation among the plurality of  
6 operations;  
7 a service application name indicating a service application for performing the  
8 operation;  
9 an input data portion indicating input data used by the service operation for  
10 performing the operation; and  
11 a conditional logic data portion indicating evaluation data conditioning performance of  
12 the next operation on evaluation of operation response data received from the  
13 service application performing the operation.

1 14. The transaction definition data structure of claim 13 wherein the conditioning  
2 logic data portion indicates at least one of a mathematical expression, a function, and a  
3 variable data item for use in evaluating the operation response data.

1 15. The transaction definition data structure of claim 13 wherein the input data  
2 indicates output response data produced by a service application previously  
3 performing one of the plurality of operations collectively defining the transaction.

1 16. The transaction definition data structure of claim 13 wherein the input data  
2 portion includes argument input data for performing the operation; the argument input  
3 data including a variable name known to the service operation performing the  
4 operation, an argument value to be assigned to the variable name, and an argument  
5 expression data portion; the argument expression data portion indicating at least one of  
6 a mathematical expression, a function, and a variable data item; the at least one of the  
7 mathematical expression, the function, and the variable data item being evaluated to  
8 produce the argument value as input to the service application performing the  
9 operation.

1 17. The transaction definition data structure of claim 13 wherein each operation  
2 data portion further comprises an operation link data portion including at least one  
3 operation identifier indicating a next operation to be performed subsequent to  
4 performing the operation; all of the operation link data portions included in the  
5 transaction definition data structure collectively indicating a sequence of operations  
6 defining the transaction.

1 18. The transaction definition data structure of claim 17 wherein the operation link  
2 data portion includes a plurality of operation identifiers indicating a plurality of next  
3 operations to be concurrently performed subsequent to performing the operation.

1 19. The transaction definition data structure of claim 17 wherein a next operation  
2 indicated by the sequence of operations collectively indicated by all of the operation  
3 link data portions may be changed by a conditional logic data portion of a prior  
4 operation evaluating operation response data received from the service application  
5 performing the prior operation.

1 20. The transaction definition data structure of claim 13 wherein the transaction  
2 definition data structure is an XML document.

1 21. A computer-implemented method for performing a transaction comprising the  
2 steps of:  
3 producing a transaction instance data structure indicating a plurality of operations  
4 constituting a transaction; the transaction instance data structure indicating a  
5 linking of the plurality of operations to indicate an operation performance order;  
6 the transaction instance data structure further indicating conditioning logic data  
7 for changing the operation performance order such that the plurality of  
8 operations is capable of being performed in more than one possible order; and  
9 for each of the plurality of operations,



10       producing an operation request message indicating input data for performing an  
11           operation;  
12       sending the operation request message to a service application to perform the  
13           operation using the input data;  
14       receiving an operation response message from the service application indicating  
15           output data from the operation; and  
16       determining a next operation to perform using the conditioning logic data and the  
17           output data of the operation response message.

1    22.    The computer-implemented method of claim 21 for performing a transaction  
2    wherein the conditioning logic data indicates at least one of a mathematical  
3    expression, a function, and a variable data item; and wherein the step of determining  
4    the next operation to perform using the conditioning logic data and the output data of  
5    the operation response message includes using the output data to evaluate the at least  
6    one of the mathematical expression, the function, and the variable data item.

1    23.    The computer-implemented method of claim 21 for performing a transaction  
2    wherein the operation request message and the operation response message include  
3    extensible markup language (XML) tags indicating data items.

1 24. The computer-implemented method of claim 21 for performing a transaction  
2 wherein the transaction instance data structure is a directed acyclic graph (DAG)  
3 including a plurality of nodes; each operation being represented by a node; the nodes  
4 being arranged in the transaction instance DAG such that paths through the transaction  
5 instance DAG indicate the more than one possible order in which the plurality of  
6 operations may be performed; and wherein performing the transaction further includes  
7 traversing a path through the plurality of nodes of the transaction instance DAG.

1 25. The computer-implemented method of claim 24 for performing a transaction  
2 wherein the path through the graph is determined at runtime.

1 26. The computer-implemented method of claim 21 for performing a transaction  
2 further including receiving a transaction request message indicating a request to  
3 perform the transaction from a requesting application residing on a first computer  
4 included in a distributed network; and wherein the service application resides on a  
5 second computer included in the distributed network.

1 27. The computer-implemented method of claim 26 wherein the distributed  
2 network is the Internet.

1 28. An article of manufacture comprising a data storage medium having computer  
2 readable instruction data embodied therein; the computer readable instruction data  
3 indicating instructions executed by a processor in a processor-controlled machine for  
4 managing transaction processing message flow among a plurality of requesting  
5 application programs and service application programs resident on a plurality of  
6 processor-controlled machines in a distributed network; the computer readable  
7 instructions in the article of manufacture comprising:  
8 a first portion of instructions which when executed causes the processor to produce a  
9 transaction instance data structure indicating a plurality of operations  
10 constituting a transaction; the transaction instance data structure indicating a  
11 linking of the plurality of operations to indicate an order of execution; the  
12 transaction instance data structure further indicating conditioning logic data  
13 conditioning execution of at least one operation such that the plurality of  
14 operations is capable of being performed in more than one possible order; and  
15 a second portion of instructions which when executed causes the processor, for each of  
16 the plurality of operations, to produce an operation request message indicating  
17 input data for performing an operation, to send the operation request message to  
18 a service application to perform the operation using the input data, to receive an  
19 operation response message from the service application indicating output data  
20 from the operation, and to determine a next operation to perform using the  
21 conditioning logic data and the output data of the operation response message.

1 29. The article of claim 28 wherein the conditioning logic data indicates at least  
2 one of a mathematical expression, a function, and a variable data item; and wherein  
3 the second portion of instructions further includes a third portion of instructions  
4 which, when executed, causes the processor, for each of the plurality of operations, to  
5 use the output data to evaluate the at least one of the mathematical expression, the  
6 function, and the variable data item in order to determine the next operation to  
7 perform.

1 30. The article of claim 28 wherein the transaction instance data structure is a  
2 directed acyclic graph (DAG) including a plurality of nodes; each operation being  
3 represented by a node; the nodes being arranged in the transaction instance DAG such  
4 that paths through the transaction instance DAG indicate the more than one possible  
5 order in which the plurality of operations may be performed; and wherein the article  
6 further includes a third portion of instructions which, when executed, causes the  
7 processor to traverse a path through the plurality of nodes of the transaction instance  
8 DAG.

1 31. A computer-implemented method for performing a transaction in a distributed  
2 computer network comprising the steps of:  
3 receiving a transaction request message from a requesting application program  
4 indicating transaction data; the requesting application program residing on a first  
5 computer in a distributed computer network;

6 obtaining a transaction definition using the transaction data included in the transaction  
7 request message; the transaction definition indicating a plurality of operations  
8 and a linking of the plurality of operations to indicate an order for performing the  
9 operations; the transaction definition further indicating conditioning logic data  
10 conditioning performance of at least one operation such that the plurality of  
11 operations is capable of being performed in more than one possible order;  
12 producing a transaction instance directed acyclic graph (DAG) using the transaction  
13 definition; the transaction instance DAG including a plurality of nodes each  
14 indicating one of the plurality of operations and arranged in the transaction  
15 instance DAG such that a path through the transaction instance DAG indicates a  
16 possible execution order of the plurality of operations;  
17 traversing a path through the plurality of nodes of the transaction instance DAG; the  
18 path including the operations to be performed; traversing a path through the  
19 transaction instance DAG including the steps of  
20 producing an operation request message indicating input data for performing an  
21 operation;  
22 sending the operation request message to a service application to perform the  
23 operation using the input data; the service application residing on a second  
24 computer in the distributed computer network;  
25 receiving an operation response message from the service application indicating  
26 output data from the operation; and  
27 determining a next operation to perform using the conditioning logic data; and

28 producing a transaction response message using the operation response messages and  
29 sending the transaction response message to the requesting application.

1 32. The computer-implemented method of claim 31 for performing a transaction in a  
2 distributed computer network wherein  
3 the transaction request message indicates a transaction definition name identifying a  
4 transaction definition; and  
5 the transaction definition is one of a plurality of transaction definitions included in a  
6 transaction definition data store; each of the plurality of transaction definitions  
7 having a transaction definition name uniquely identifying the transaction  
8 definition.

1 33. The computer-implemented method of claim 31 for performing a transaction in a  
2 distributed computer network wherein the transaction request message, the operation  
3 request message, the operation response message and the transaction response message  
4 are XML documents.

1 34. The computer-implemented method of claim 31 for performing a transaction in a  
2 distributed computer network wherein no more than one transaction request message is  
3 received from the requesting application to initiate a transaction and only one  
4 transaction response message is sent to the requesting application indicating output  
5 data from performing the transaction.

1 35. A distributed transaction processing system comprising:  
2 a plurality of service application programs each capable of performing an operation;  
3 a data store including a plurality of transaction definitions; each transaction definition  
4 indicating a transaction definition name uniquely identifying the transaction  
5 definition and a plurality of operation definitions indicating a plurality of  
6 operations constituting a transaction;  
7 a requesting application program; the requesting application program producing a  
8 transaction request message indicating a transaction definition name identifying  
9 one of the plurality of transaction definitions included in the data store; and  
10 a computer having a memory device for storing a process automation application; the  
11 process automation application receiving the transaction request message  
12 indicating the transaction definition name from the requesting application  
13 program and using the transaction definition name to obtain the transaction  
14 definition from the data store; the process automation application producing an  
15 operation request message for each operation definition included in the plurality  
16 of operation definitions and sending the operation request messages to at least  
17 one service application program;  
18 the at least one service application program sending an operation response message  
19 indicating an output of performing an operation to the process automation  
20 application in response to receiving an operation request message;

21 the process automation application producing a transaction response message using the  
22 operation response messages and sending the transaction response message to the  
23 requesting application.

1 36. The distributed transaction processing system of claim 35 wherein the  
2 transaction definition, the transaction request message, the operation request message,  
3 the operation response message and the transaction response message are XML  
4 documents.

1 37. The distributed transaction processing system of claim 35 further including a  
2 transaction instance directed acyclic graph data structure including a plurality of  
3 nodes; the process automation application using the transaction definition to produce  
4 the directed acyclic graph data structure; each of the plurality of operation definitions  
5 being represented by a node in the directed acyclic graph data structure; and  
6 wherein the process automation application traverses a path through the transaction  
7 instance directed acyclic graph data structure to process the transaction.

1 38. The distributed transaction processing system of claim 37 wherein the plurality  
2 of operation definitions indicate more than one processing order for processing the  
3 operations; the transaction instance directed acyclic graph data structure indicating  
4 more than one path through the nodes; and wherein the process automation application  
5 determines the path to traverse through the directed acyclic graph data structure to  
6 process the transaction at runtime.



1 39. The distributed transaction processing system of claim 35 further including a  
2 second computer having a memory device for storing at least one of the service  
3 applications; the second computer and the computer storing the process automation  
4 application being included in a distributed computer network.

1 40. A processor-controlled machine for managing transaction message flow in a  
2 distributed computer network; the machine comprising:  
3 data communications circuitry connected to a network communications device for  
4 receiving signals indicating request messages from at least one remote processor-  
5 controlled machine and for sending signals indicating response messages to at  
6 least one remote processor-controlled machine;  
7 a processor connected for receiving the signals from and for sending the signals to the  
8 data communications circuitry; and  
9 memory for storing data; the data stored in the memory including  
10 instruction data indicating instructions the processor can execute; and  
11 transaction definition data; the transaction definition data indicating a plurality of  
12 operations and a linking of the plurality of operations to indicate an order  
13 for performing the operations; the transaction definition data further  
14 indicating conditioning logic data conditioning performance of at least one  
15 operation such that the plurality of operations is capable of being  
16 performed in more than one possible order;  
17 the processor being further connected for accessing the data stored in the memory;

18 the processor, in executing the instructions, receiving signals via the data  
19 communications circuitry indicating a transaction request message from a  
20 requesting application program indicating transaction data;  
21 the processor, further in executing the instructions, obtaining from memory the  
22 transaction definition data using the transaction data included in the transaction  
23 request message;  
24 the processor, further in executing the instructions, producing a transaction instance  
25 directed acyclic graph (DAG) using the transaction definition data; the  
26 transaction instance DAG including a plurality of nodes each indicating one of  
27 the plurality of operations and arranged in the transaction instance DAG such  
28 that a path through the transaction instance DAG indicates a possible execution  
29 order of the plurality of operations;  
30 the processor, still further in executing the instructions, traversing a path through the  
31 plurality of nodes of the transaction instance DAG; the path including the  
32 operations to be performed; the processor, in traversing a path through the  
33 transaction instance DAG,  
34 producing an operation request message indicating input data for performing an  
35 operation;  
36 sending via the data communications circuitry signals indicating the operation  
37 request message to a service application to perform the operation using the  
38 input data;

39 receiving via the data communications circuitry signals indicating an operation  
40 response message from the service application indicating output data from  
41 the operation; and  
42 determining a next operation to perform using the conditioning logic data;  
43 the processor, still further in executing the instructions, producing a transaction  
44 response message using the operation response messages and sending the  
45 transaction response message to the requesting application via the data  
46 communications circuitry.

**ABSTRACT**

1  
2 A process automation application, referred to as a commerce exchange server,  
3 for sending transaction messages between application programs uses a transaction  
4 definition data structure for specifying the component operations and processing logic  
5 that comprise the transaction. The data structure specifies one or more operations that  
6 constitute the transaction, instructions for producing the input data needed for each  
7 operation, and conditional logic for specifying constraints on the sequence of  
8 operation execution. The conditional logic may include one or more expressions,  
9 ranging from simple to complex, including variables, math operations and functions,  
10 that are evaluated using the inputs or outputs of one or more prior operations to  
11 determine execution order of subsequent operations. The transaction definition data  
12 structure may also provide for broadcast operations and for conditioning the success of  
13 their execution. In an illustrated implementation, the transaction definition data  
14 structure is an XML (Extensible Markup Language) document in the form of a  
15 directed acyclic graph (DAG). A transaction service architecture provides for storing  
16 transaction definitions that define specific types or categories of transactions in a  
17 transaction database, and for matching a transaction definition to a transaction  
18 definition identifier from a requesting application. The transaction service then builds  
19 a transaction instance DAG to perform the transaction, produces the messages needed  
20 for performing the transaction, and manages the message flow to and from the service  
21 applications that perform the constituent operations of the transaction.

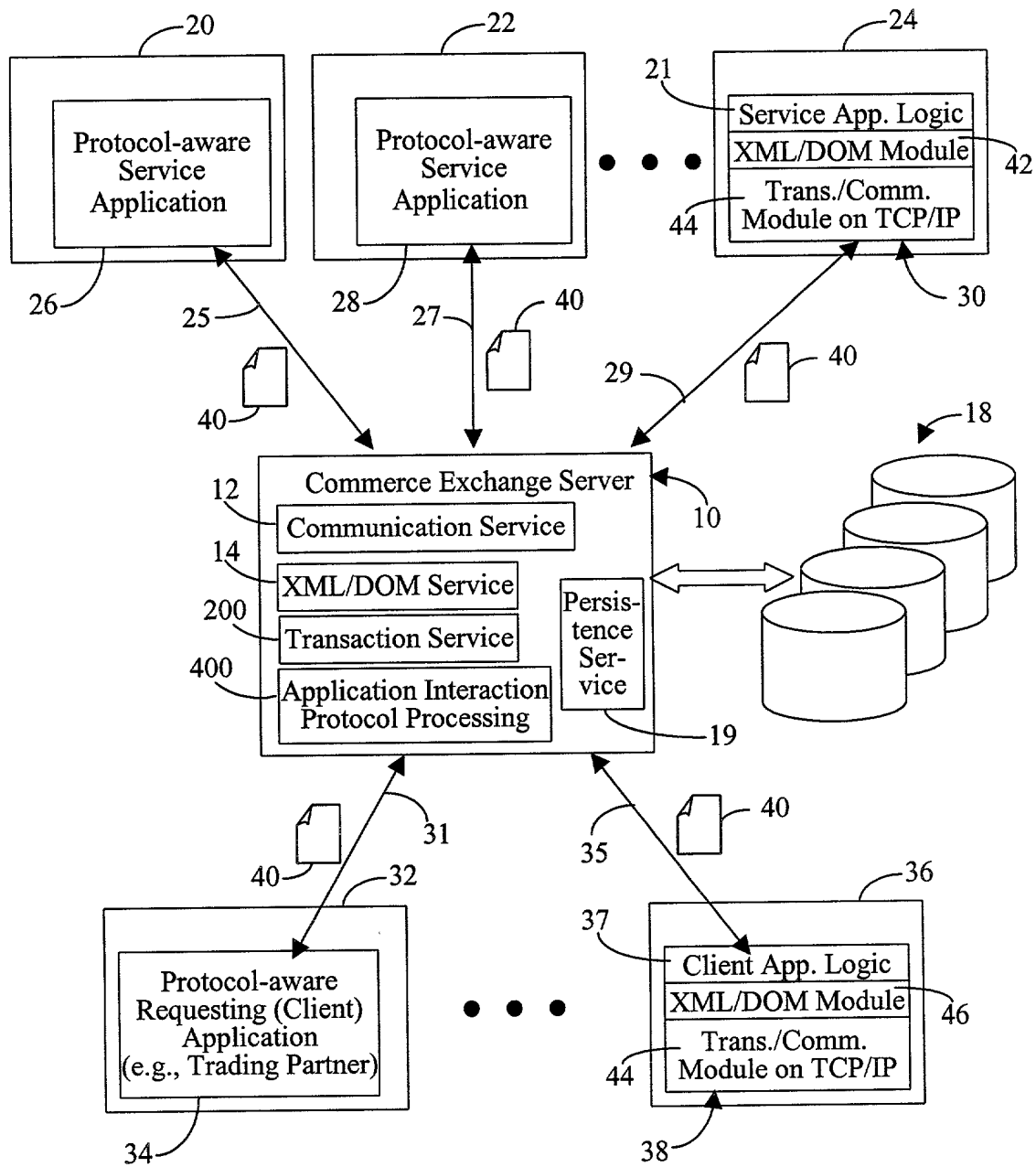


FIG. 1

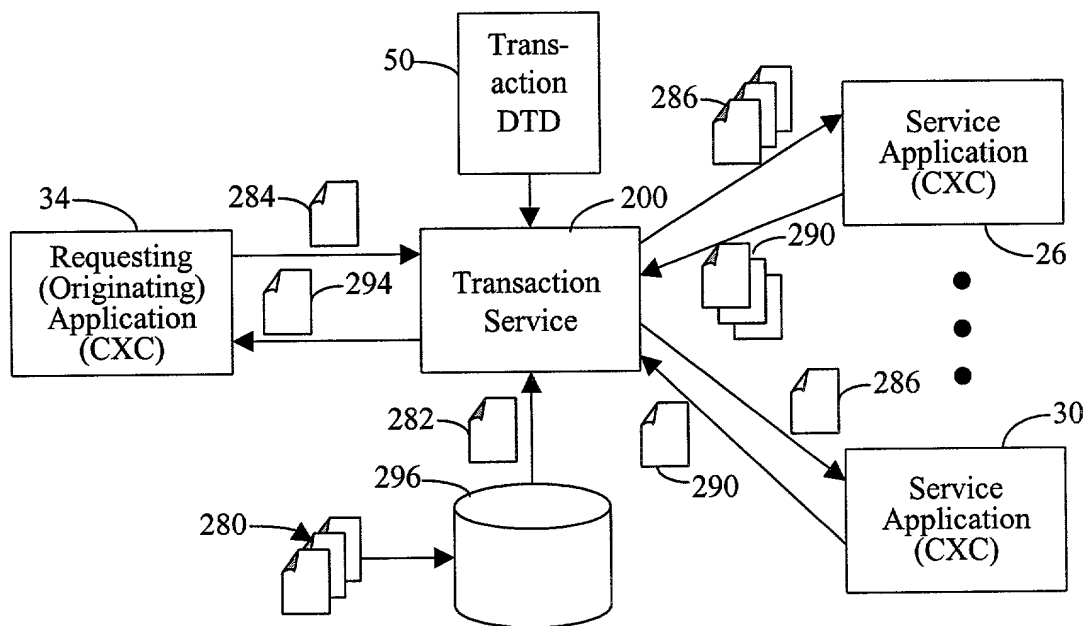


FIG. 2

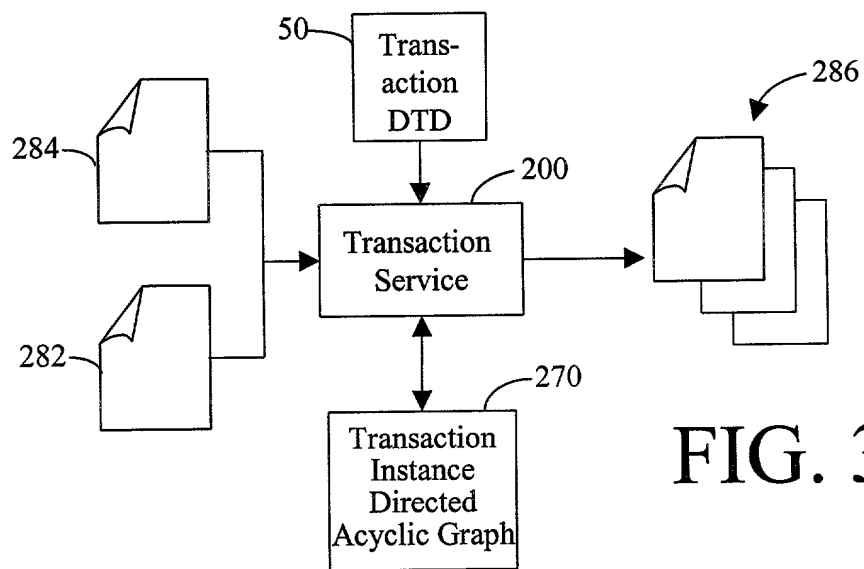
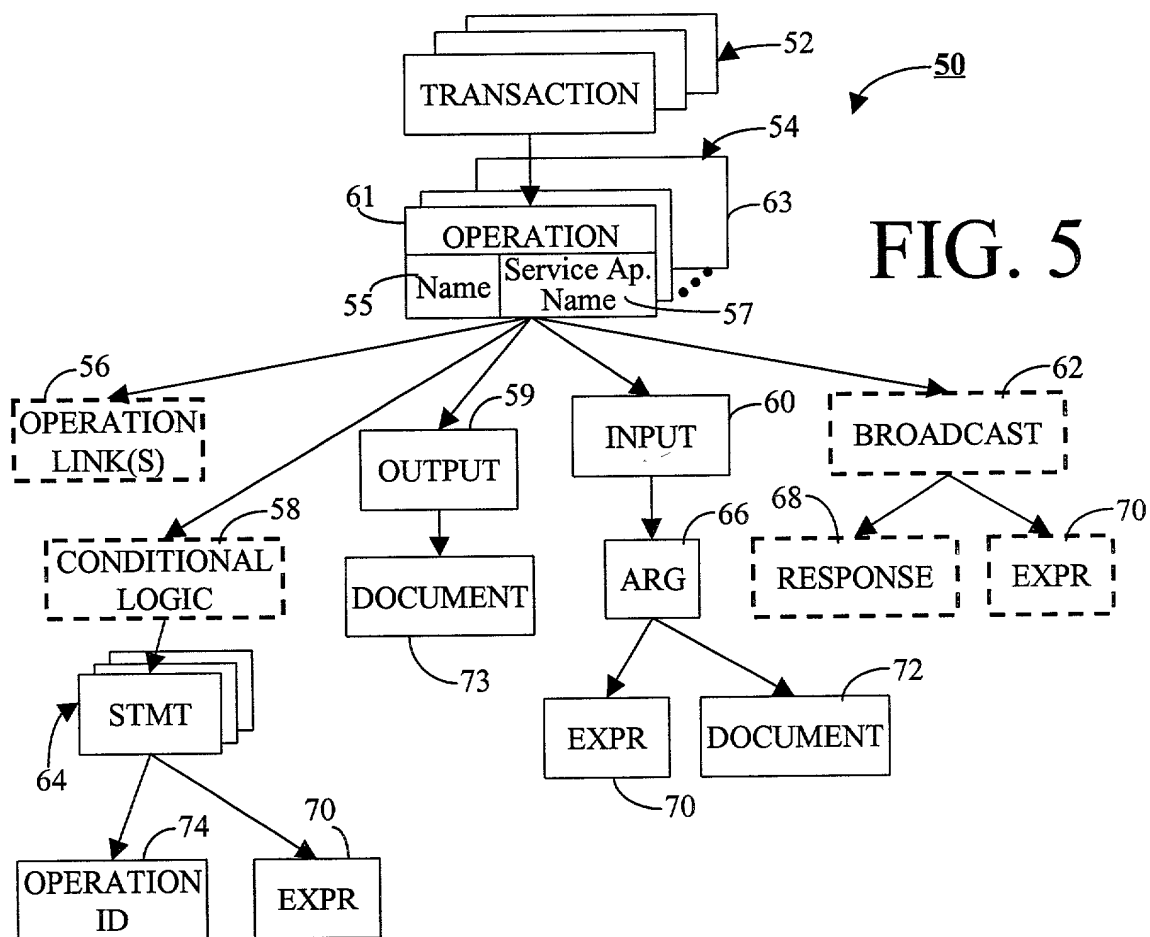
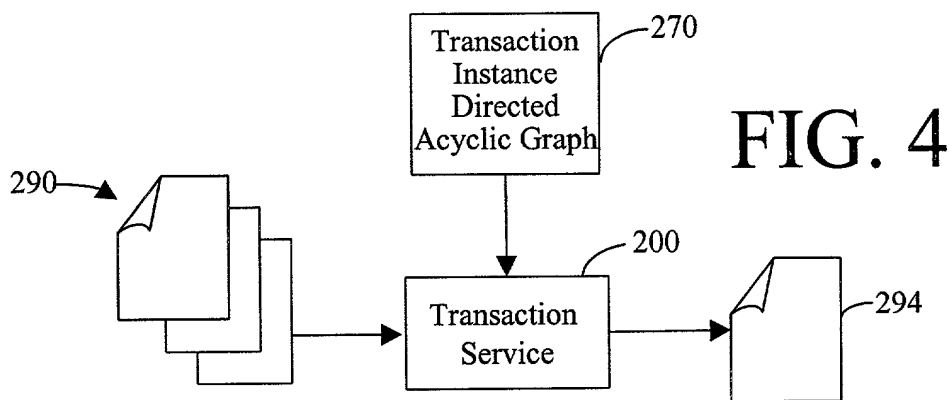


FIG. 3



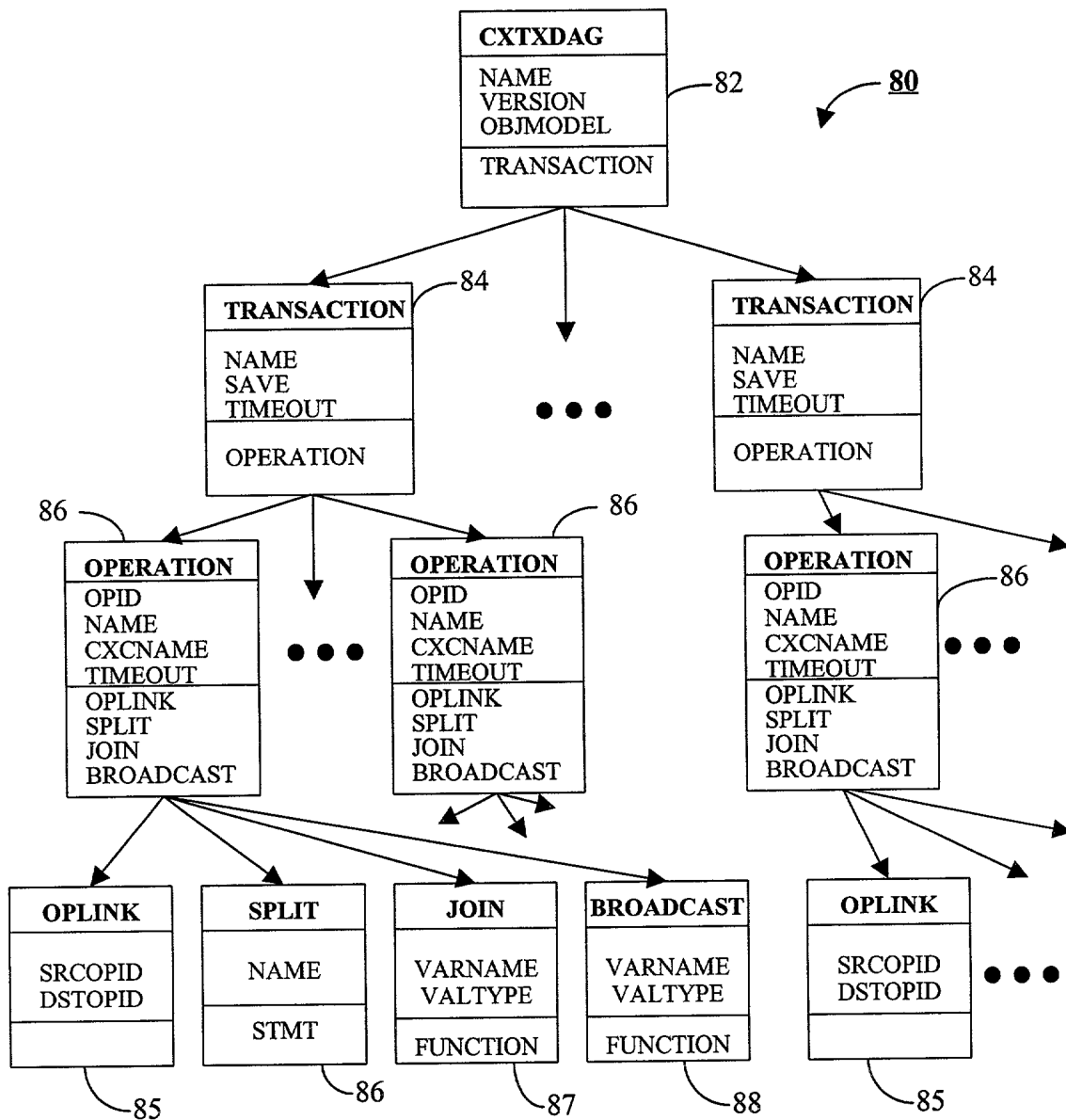


FIG. 6



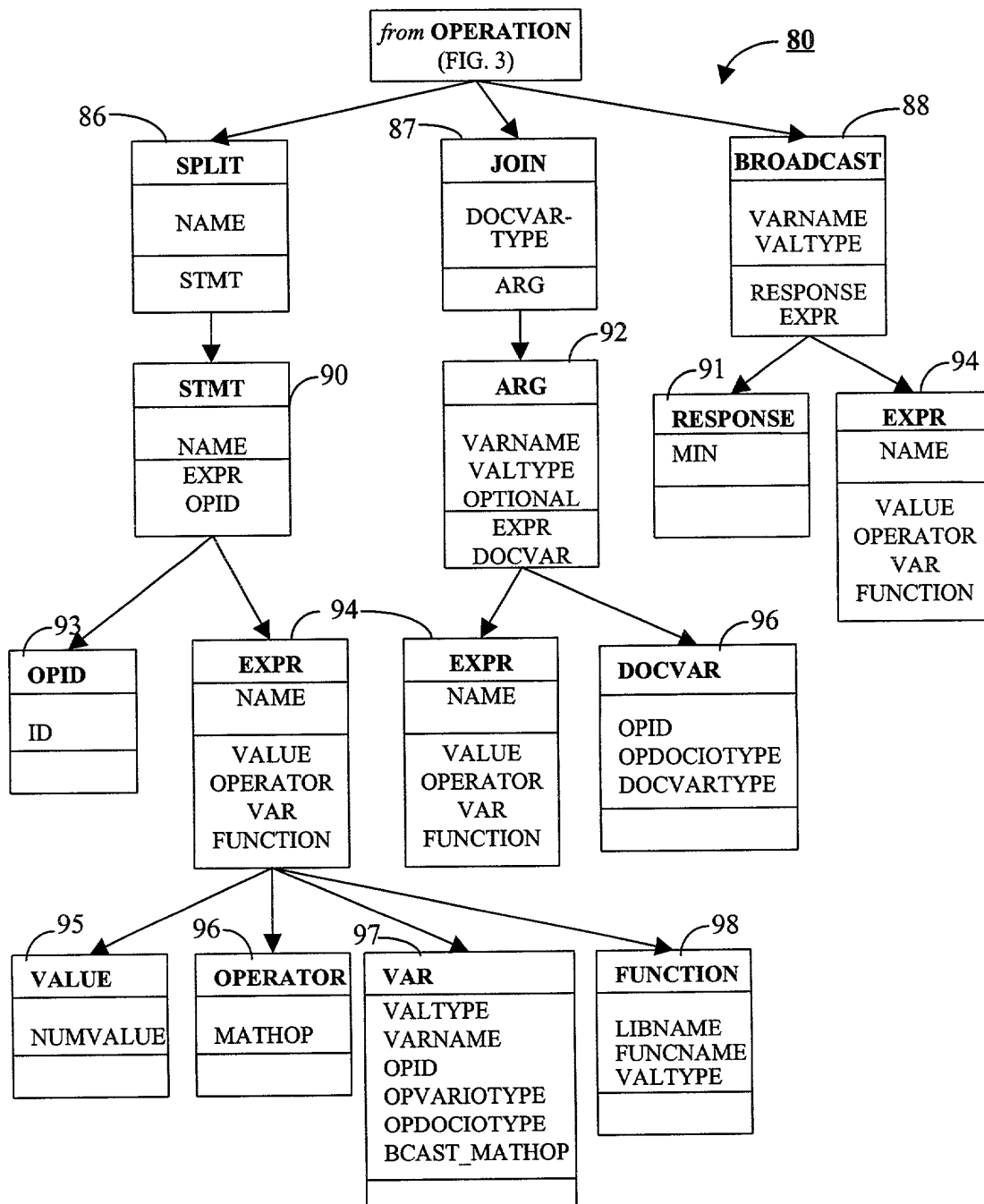


FIG. 7

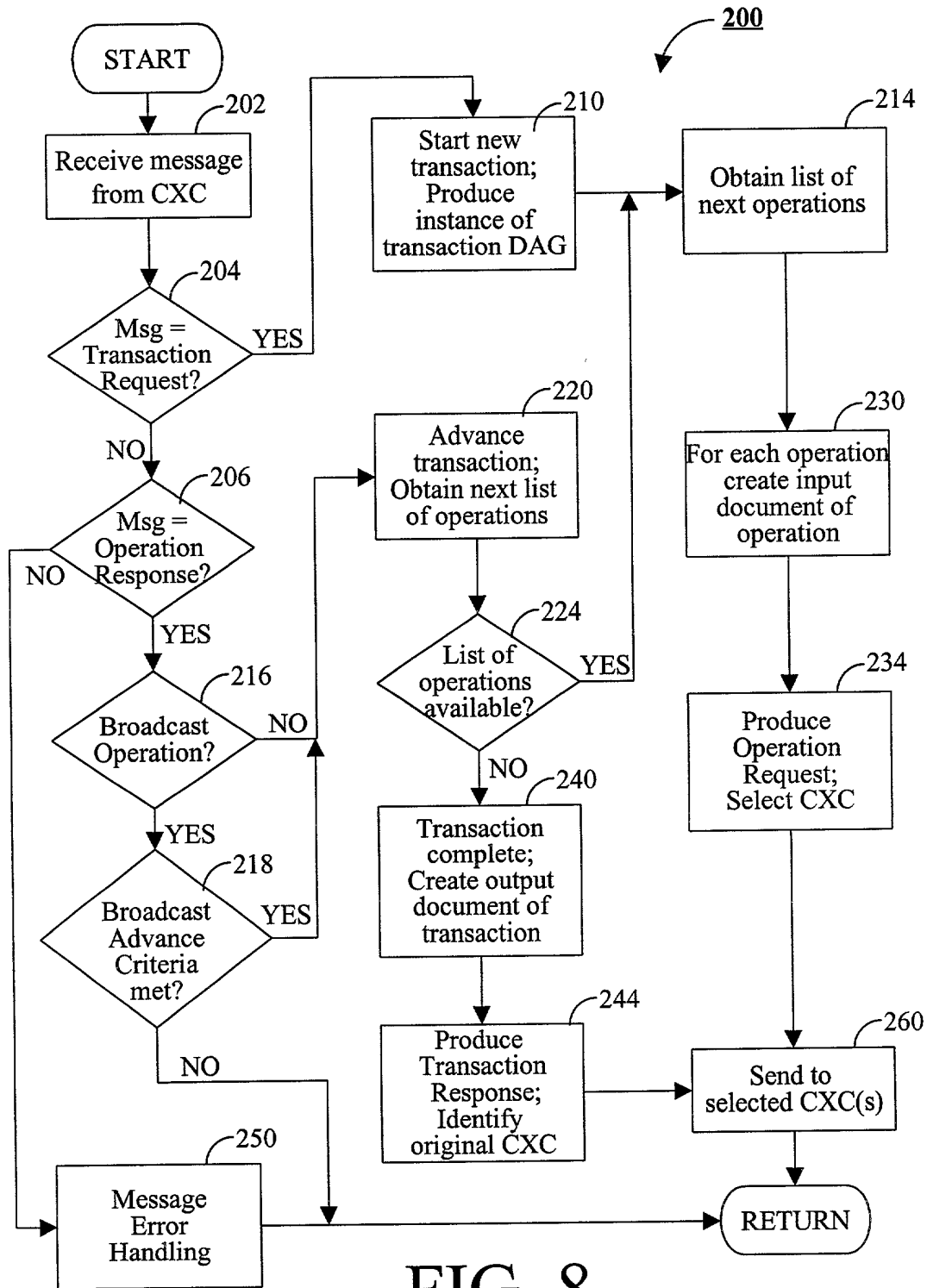


FIG. 8

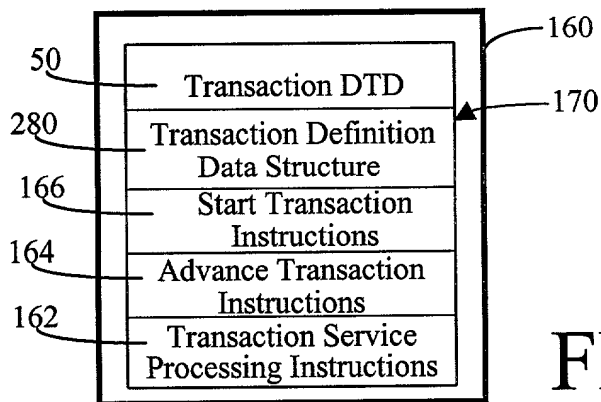
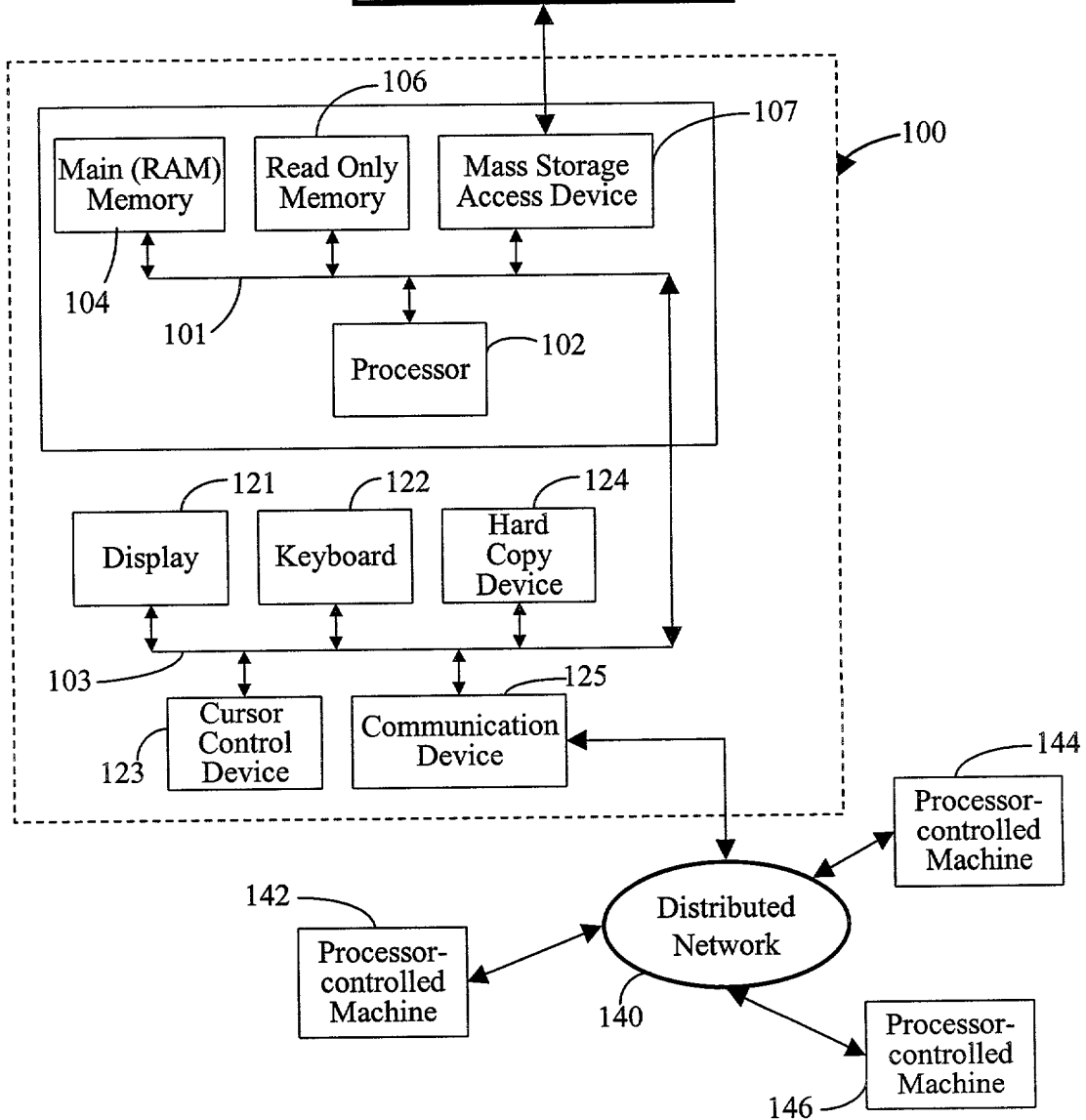


FIG. 9



UNSIGNED

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DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

TRANSACTION DATA STRUCTURE FOR PROCESS COMMUNICATIONS AMONG NETWORK-DISTRIBUTED APPLICATIONS

the specification of which

☒ is attached hereto.

N/A was filed on xx/xx/xx as United States Application Number xx/xxx,xxx

N/A or PCT International Application Number N/A and was amended on N/A (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Applications

Priority Claimed

			YES	NO
N/A (Number)	EP (Country)	xx/xx/xx (Date Filed)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
 (Number)	JP (Country)	xx/xx/xx (Date Filed)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
N/A (Number)	N/A (Country)	N/A (Date Filed)	<input type="checkbox"/>	<input type="checkbox"/>

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional applications listed below

N/A (Application Number)	N/A (Filing Date)
N/A (Application Number)	N/A (Filing Date)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

N/A	N/A	N/A
(Application Number)	(Filing Date)	(Status-Patent, Pending, Abandoned)
N/A	N/A	N/A
(Application Number)	(Filing Date)	(Status-Patent, Pending, Abandoned)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Title 37, Code of Federal Regulations, Section 1.56

(Combined Declaration & Power of Attorney)

Serial No.: xx/xxx,xxx

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Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) Prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent



with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the

application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.